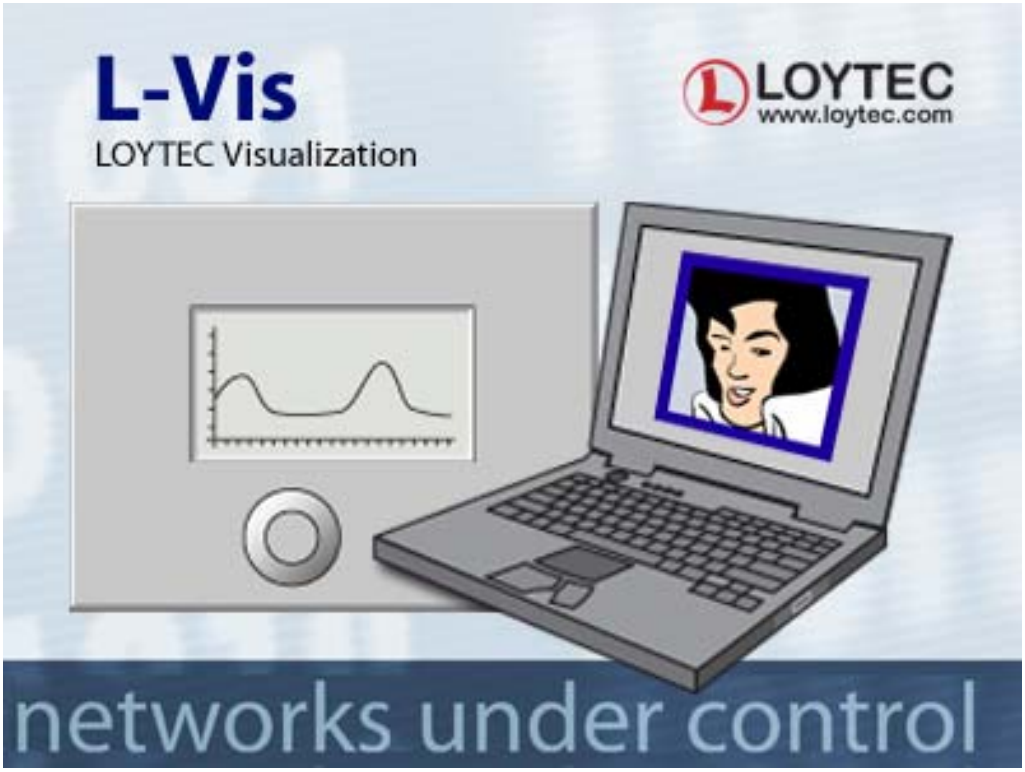
L-Vis

User Manual

LOYTEC electronics GmbH



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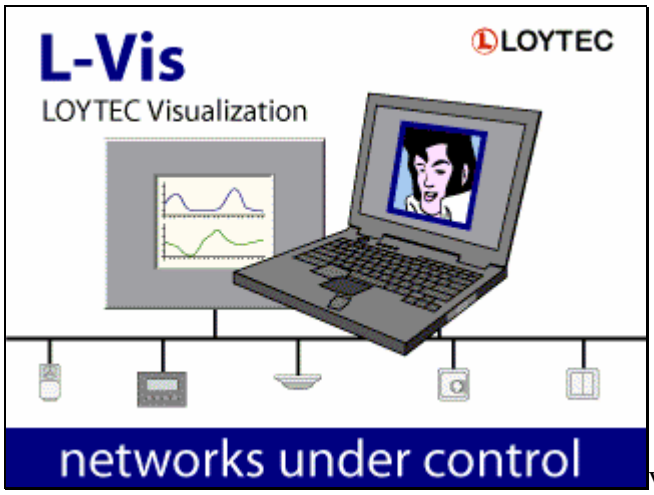
Introduction

What is L-Vis?



Vis is a highly flexible and easy to configure device to display and control data in BACnet and CEA709 networks. The L-Vis configuration software can be run as a standalone program as well as an LNS® plug-in and supports the use of both static and dynamic network variables in a project to allow easy integration in any kind of CEA709 network.

The key features of the L-Vis device family are:

- 320x240 graphical color touch LCD display with 256 colors (VGA Palette) and a dimmable CFL backlight.
- Simple, graphical programming via the supplied configuration software.
- Support for alarming, scheduling and trending.
- Support for the UCS-16 character set of the Unicode standard (ISO-10646), to allow for the design of projects in any language, including Chinese, Japanese, and Korean (CJK).
- Display of data as numeric value, user-defined text or graphic elements, horizontal and vertical bars or trend logs. A special element is available to display date and time in form of digital or analog clocks.
- Input of data via a numeric keypad, direct drag of a bar or selection from a dropdown list of texts or graphic elements.

- Mapping of values to colors, to allow an element to change color depending on the current value.
- Supports layers and transparency for all display elements. Layering is simply defined by the order of objects in the tree view, which may be changed easily by moving the objects around as required.
- Support for numeric operations on data points, including a simple if/else statement.
- Input voltage: 24V AC or DC

The LVIS-3E100 model (CEA709) also provides:

- Up to 512 network variables and alias variables.
- Up to 512 address table entries.
- FT-10/LPT-10 or Ethernet-IP852 operation selectable via a jumper on the device. When in FT-10 mode, the device can still be reached via its Ethernet port for fast project download.
- A lamp actuator object to control the backlight from the network. This object was used to control the internal relay on the older LVIS-3ECTB devices.
- A switch object to provide a standard switch and dimmer function, as available on other CEA709 devices. The switch input for this object is the IN0 connector. Both IN0 and IN1 inputs are also available as system registers, for internal use.
- A temperature sensor object which outputs the current value of the external temperature sensor (optional).
- A real time keeper object which outputs the current system time.
- 8 L-Vis functional blocks which can be used to place static or dynamic NVs related to the data points used in the project.
- Network scanning to find other device on the network and help in creating the required network variables on L-Vis.

The LVIS-ME200 model (BACnet) provides:

- Up to 512 server objects, accepting COV subscriptions. Available object types are analog, binary and multi-state, each as either input, output, or value object.
- BACnet/IP or MSTP connectivity (jumper selectable).
- Network scanning to find other devices and their objects in the network and use them on the L-Vis device without the need to manually enter device and object instance numbers.
- Supports COV subscription and polling of remote server objects with automatic selection of the best method (COV if available).

Scope

This manual covers the L-Vis device family. Currently available are the LVIS-3E100 (CEA709 model) and the LVIS-ME200 (BACnet model), both equipped with a 320x240 color touch display using the standard 256 color VGA palette.

Getting Started

Installing the L-Vis Configuration Application

To install the L-Vis Configuration software, execute the setup program and follow the instruction of the installation wizard. The setup program adds an entry for the L-Vis Configuration software to the start menu. For the use with LNS® based network management tools, it registers the configuration software as an LNS® plug-in. Before the LNS® plug-in can be used in a network management tool, it has to be registered in the LNS® project. Please refer to the documentation of your network management tool how to register an LNS® plug-in in a network management project. During the registration process of the L-Vis Configuration software plug-in, LNS® device templates are created for the FT10, and IP10L (Ethernet) versions of the device.

Connecting to the Device

There are several ways in which the configuration software can be run and used to configure a device. While this is straight forward for BACnet models, it is important to know the advantages and limitations of each method for CEA709 devices.

CEA709 Devices

CEA709 devices may be configured in several different ways:

- Through LNS® (software run as LNS® plug-in).
- Via a TCP/IP connection (using FTP).
- Via an CEA709 connection (FT-10 or IP852).

Each of these methods has some advantages and some limitations in what they can do. Please see the following detailed description of the individual connection methods.

LNS® Connections

This method connects to the device from within the LNS® based network management tool. The software is run as a plug-in and all communication with the device is done through LNS®, meaning that you can use any network interface which is supported by LNS®.

If your device is integrated into the network using an LNS® based tool (your device is managed by LNS®) and you need to add or remove static network variables from your project or otherwise change the static interface of the device, you **must** use this connection method to download your project, since the configuration software needs to do several adjustments to the LNS® database during this process.

If your changes to the project do not cause changes to the static network interface, for example you are just working on the graphics, adding or modifying controls and so on, it is more efficient to use one of the other connection methods. The configuration software will detect any change in the static network interface beforehand and display a warning before you commit to the project download.

ADVANTAGES:

- No need to set up TCP/IP connectivity.
- Easy device selection from within your management software.
- Automatically updates the LNS® database and re-commissions the device, if necessary.
- Functions to export and import current bindings to and from the device into CSV files.
- Any dynamic network variables created on the device will show up as usable data points in your project, including the name of the functional block in which they are located.

LIMITS:

- Download of large projects or firmware upgrade is slow, due to the limits of the communication channel. This is especially true for devices in FT-10 mode.

TCP / IP (Ethernet) Connections

This method connects to the device through a standard TCP/IP channel. Data is transferred using the FTP protocol, therefore the PC running the configuration software must be able to establish an FTP connection to the device.

TCP/IP connections are possible even when the device operates in FT-10 mode, since the IP port is always active. The IP address, network mask and gateway must be configured via the setup menu on the device. The device must be restarted once for the new settings to take effect.

In the configuration software, the IP address or DNS name of the device can be used to establish a connection. Each connection can be named and saved in a connection list, which is stored in the system so that the list is available when the software is run the next time.

ADVANTAGES:

- Very fast data transfer, suitable for large projects.
- Faster startup of the device, because the project data is transferred and stored uncompressed, so the device does not need to decompress the project before it can be loaded.
- Communication is possible even when the device is not commissioned or otherwise not reachable on the CEA709 port.
- No LNS® or special network interface hardware is required. The standard Ethernet port which is available on every PC is enough.

LIMITS:

- No connection to LNS (if present) and therefore no way to update the database in case the new project changes the static interface of the device. Projects which add or remove static network variables or otherwise change the static interface may not be loaded via this method if the device is part of an LNS database, since the database will be out of sync after the download and cannot be repaired by

the user (only the configuration software can apply the necessary changes).

- Any dynamic network variables which were created on the device using a network management tool will show up as usable data points in the project, but the functional block in which they were created will be unknown, since the device itself does not have this information (only the management software would know).

CEA709 (FT-10 / CEA852) Connections

In this mode, the communication channel is CEA709 via a LOYTEC NIC such as a NIC-USB, NIC-PCI or NIC-852. The device must first be commissioned (assigned a network address), either by using the same network management tool as used for the other nodes in the network or by entering a suitable unused address in the CEA709 setup menu. In the connection dialog of the configuration software, the address of the device may either be entered manually, or can be detected automatically by either entering the unique node ID or by pressing the service pin button on the device. Once the address is known, the connection may be named and saved just like the TCP/IP connections, so that the procedure is only necessary when the address of the device changes.

Connecting via CEA709 is most suitable when the device is not connected to the IP network and a non-LNS network management tool is used for integration.

ADVANTAGES:

- Works even when the device is not connected to an IP network, thus no need to set up TCP/IP settings for the device.
- Download is faster compared to LNS® connections, due to an optimized file transfer protocol.

LIMITS:

- Only works when the device is commissioned. A download of a new project which changes the static interface of the device will therefore break the connection, since the device will have to reset its CEA709 network configuration in that case. The device must then be re-commissioned in the network management tool and the connection must be re-established.
- Especially in FT-10 mode, project downloads can still be slow. The same is true for firmware downloads. If possible, the TCP/IP connection method should be used for such tasks. Transfer speed is considerably improved when there are no routers with limited buffer size between the PC and the device. Routers which are able to handle large packets (254 byte) will have no real impact on the transfer speed. Routers which allow a maximum packet size of 64 bytes only will degrade the transfer speed.
- Only network interface hardware from LOYTEC can be used for this type of connection. Any LOYTEC NIC may be used to run the configuration software, that is, the software is not registered to a specific network interface hardware.

BACnet Devices

To configure BACnet devices, the software is always run in standalone mode and a connection to the device is made over TCP/IP. The PC must be able to establish an FTP connection to the device (check firewall rules if necessary).

Quick Start Tutorial for CEA709 devices

This tutorial describes the steps to create a first demo project and load the project into the L-Vis device. Since the CEA709 models are the more complex devices, requiring extra steps compared to the BACnet models, the tutorial is tailored for CEA709 devices. To use this tutorial for BACnet devices, just skip CEA709 related steps (as mentioned in the tutorial for such steps).

The tutorial assumes that the configuration software is already installed and the LNS® plug-in is registered as described in the prior section (of course only if you are using CEA709 devices). For this example we use the LonMaker® 3.1 network management tool to commission the L-Vis device in the network. Other network management tools, which are based on LNS® 3 or above, which support dynamic network variables and the LNS® Plug-in Interface can be used as well for this tutorial (e.g. Newron's NL220, SPEGA's Alex 3 Professional). BACnet models do not need to be commissioned and therefore do not need any extra network management tool.

Step 1: Create the L-Vis device (CEA709 only)

Add the L-Vis device to your network project. Since the L-Vis configuration plug-in already creates the device templates, the device configuration can be read from the device template. Choose the device template which matches the network interface mode (FT-10 or IP-10L) of your device. The Node ID of the device can be entered manually. Optionally, a service pin message can be sent by pressing the status button located at the bottom of the device, or by selecting the Send Service Pin Message command in the Setup→Commands menu of the L-Vis device (see Setup Menu).

NOTE: Do not integrate the device into your project by uploading the device interface properties from the device before you registered the plug-in. This is important because if you upload the definitions from the device, you will create a template of your own and the configuration software will then fail to create the real device template, once you register it. In this case, you must remove the device and the template from the database and re-run the plug-in registration.

Step 2: Create Dynamic NVs (CEA709 only)

In this example, we will create two dynamic network variables of type SNVT_switch on the device, one input and one output, and bind them together (turnaround binding) to show how to display and send out data.

NOTE: If your network management tool does not support dynamic NVs, just skip this step. The required data points will then be created from within the configuration software in a later step (as static NVs).

First, we need a functional block to place the new network variables in. Create one of the 8 available L-Vis functional blocks (for example L-Vis[0]) to hold the two variables. Next, create the two switch variables. For the complementary NV required to create the dynamic NV, browse to the Switch object of your L-Vis device and select one of the two switch variables available there (the direction does not matter).

NOTE: Make sure to set the poll attribute to CLEAR when you create the output variable, otherwise you will not be able to send out any values through this NV. Also, the poll attribute of the input NV should be set, so that L-Vis is able to fetch an initial value when it boots up.

Now bind the output NV to the input NV, so that we can send/receive values.

Step 3: Start the L-Vis Configuration Plug-in

Run the configuration software in plug-in mode from within your network management tool. Open the context menu of the L-Vis device block in your drawing and select Configure to start the configuration software.

NOTE: For network management tools which do not support plug-ins, start the program in standalone mode and connect to your device via TCP/IP.

The configuration software contacts the device, finds out what model and firmware version it is, selects the correct settings and disables the corresponding menus, so that you may not change them. The main window will show an empty L-Vis project.

When the L-Vis configuration software is started in plug-in mode, the list of dynamic network variables in the device is automatically read in and a list of data points is generated, which will be used in a later step.

NOTE: In case the device was not commissioned yet, or there are other communication problems, the plug-in will display a warning message, saying that it could not communicate with the device and therefore was not able to determine model or firmware version. In this case, you have to commission the device or find out why it cannot be commissioned. Typical errors are devices in the wrong mode (jumper set for CEA852 but connected to FT-10 or vice versa) or communication problems on the channel itself. Especially on a channel as complex as CEA852, there are a number of possible reasons why you may not be able to communicate with the device.

The main window is divided in tree major sections:

Tree View: On the left side of the main window is a tree view showing all objects you created so far and how they relate to each other, for example a menu object may have menu item objects attached to it, a menu item object may have page objects and sub-menu objects attached, and a page object contains the elements to display and enter data (these elements are called *controls* in this manual). You may navigate through this tree and select an object from it or drag and drop objects to move them around in the hierarchy, for example grab a control from one page and drop it on another page. An empty project contains only a root menu and a few folder objects, where global objects can be placed, which are not directly related to the user interface, for example alarm generators.

Property View: On the top right of the main window is a property view, which shows a number of property pages, where you can adjust the properties of the currently selected object. The number and kind of property pages changes according to the selected object, but some of the more basic property pages are available all the time. Feel free to browse through the available pages and see what you can adjust there.

LCD Preview: To the lower right of the main window is the preview of the project as seen on the LCD when the project is downloaded. This is not a functional simulation of the L-Vis device, but a layout guide and preview of individual menus and pages. The preview changes according to the currently selected object. Since the configuration software comes with a library of the layout code used in the various firmware versions of the device, the preview is always accurate to the pixel. Should the layout or appearance of controls change with firmware versions, the configuration software is able to track these changes and display the page exactly as it will appear on the device you are currently connected to.

NOTE: You may **select, move, and resize** your controls directly inside the LCD preview. Also, there are context menus available for each control, which you can open by a right click on the control in the preview. The cursor keys can be used to move controls one pixel at a time and to resize the control, when the shift key is held down.

Step 4: Create Menu Structure and Pages

With this basic information, we are now ready to design a simple test page for this tutorial. The empty project shows the root menu with no entries (menu items). You may change the name of the root menu as well as its colors and other properties, such as the width of the menu or its scroll-bar using the property pages to the right of the tree view (make sure the root menu object is selected, which should be the case right after you started the plug-in).

Now we add a menu item to the root menu. To do this, right click on the root menu object in the tree view and select *Add Item* from the context menu. A new menu item is created and connected to the menu object. The new menu item is automatically selected, so that you may browse the property pages and see what you want to change. We should first change the name of the item object in the *Name* box of the **General** property page, for example to 'Item 1'. This changes the name of the object in the object tree and has no effect on the appearance of the menu item on the device. To change the text of the item itself, go to the **Common Properties** page and change the contents of the *Text* box to 'Test 1'. The display in the preview window changes as you type, so you can immediately see the results. You may want to change the font to the 12x16-ROM-Fixed-R font, so you get a larger item which is easier to select on the touch screen.

Repeat the steps above to add another menu item and call it 'Setup'. Again, change the *Text* of the item to read something like 'Setup' and change the font to make the item a comfortable size. This item will be used to enter the devices setup menu.

NOTE: The device will check the last item of the root menu and see if it has any pages or sub-menus attached to it. If the item has no further objects attached (this is called a *return item*), then the device will connect its setup menu to this item. If the item is used, the device will create a default item to reach the setup menu, but this will most likely not fit the design of your other menu items, so it is best to always add a setup item yourself and configure it the way you want it to look.

Finally, we add a page to the first of our two menu items (Item 1). This page will be displayed, when the user selects the menu item from the root menu. Open the context menu of the menu item (right click on 'Item 1' in the tree view) and select *Add Page*. In order to see this page right after the device started, we want to make this the projects default page. Open the context menu of the page in the tree view and select *Set as Default*.

Step 5: Add Controls

The next step is to place some objects on the page which will allow us to view and control the values of our network variables. These objects are called *controls* in this manual, since they allow the user to control the data points and display their current value. A number of different control styles are available to choose from. In this example, we want to display the current status of the switch input using a text control for the state and a numeric control for the value. To control the switch output, we use a bar control for the value and a bitmap control for the state.

To create the required controls, either right click on the page object in the tree view and choose the control type you want from the context menu, or select the page in the tree view and right click in the LCD preview area to reach the same context menu. Add one text control, one bitmap control, one numeric and one bar control to your page.

Now place the controls on your page so that they do not overlap each other. Grab and drag them with the mouse or enter position and size in the *Screen Coordinates* section of the **Common Properties** page. To resize the controls with the mouse, move the pointer to the lower right corner of the controls area in which the value is displayed, that is, disregard any decorations around the value area, like the scale of a bar control. For most control types, the value area fills the entire space of the control, except for the selection frame. For more complex controls, like bars and trend logs, you can view the value area by changing the *Container* color on the **Color** property page. Then grab the control at the lower right corner of the container area.

NOTE: The position and size you set on the **Common Properties** page also refers to the value area of the control, not to the selection frame around it. This is done so that for example the width and height of a bar does not change when you enable or disable tick marks or scale. These are just seen as decoration which can be turned on and off while the area of the value display remains stable.

Adjust the properties of each control as you like or leave them at the defaults, which should be fine for this demo. Bitmaps will be added to the bitmap control in a later step.

Step 6: Connect the Data-Points

At this point, we should start to connect some data points to our controls. Especially for text and bitmap controls, it helps to connect the data points early, since the configuration of the controls property will depend on the data point connected (you will see why this is the case in a minute).

To add a data point to a control, select *Add Data Point…* from the controls context menu (same procedure as before). A new dialog will appear which is used to manage and select data points. This dialog will be explained in detail later on, for now we just use it to select our data points, which should have been created for us already. Select the folder *Local NVs* from the tree view at the left of the dialog. There should be two items, one for the input NV and one for the output NV we created in step 2.

NOTE: In case you created the dynamic NVs after you started the plug-in, the data points will not be there yet. In this case, close the data point dialog and push the button two positions right from the connect button. The tool-tip of this button reads ‘Update Data Points’. It will re-scan the currently available dynamic NVs on the device and create the required data points for you. If you added NVs while the plug-in was open, hit the update button to get the required data points added to your project automatically.

If your network management tool does not support dynamic NVs, you have to create static NVs now. Right click in the top right area of the data point manager (where the list of data points is shown) and select *New Datapoint…* to open the data point creation dialog. From the list of standard NV types, select snvt_switch and create one input and one output NV.

From the two items available in the data point list, select the input data point and expand its items by a left click on the small plus sign left of the data point. The expanded view will show two sub-elements, one for the state component of the NV and one for the value component. A data point is selected by a double click or by selecting one or more points and clicking the OK button.

You should now use the above procedure to add the state of the input NV to the text control, the value of the input NV to the numeric control, the state of the output NV to the bitmap control and the value of the output NV to the bar control.

NOTE: When you add the state of the input NV to the text control, another object called a mapping table will be created automatically and will be initialized to map the three known states of the switch state to standard state texts. You may select this mapping table and change the texts as well as assign different colors to the individual texts in the mapping table. Mapping tables will be discussed in detail later on, for now you can leave the table alone.

All the controls should now have one data point connected, with the text control and the bitmap control having a data point and a mapping table. The bitmap control needs some more work, since we need to assign graphics to the individual values of the connected data point.

To do this, select the mapping table object which was created and attached to the bitmap control. On the **Mapping** property page, select one of the entries in the list, for example the entry for the value -1, which maps to the text SW_NUL. Click on the button *Select Bitmap…* and select a suitable graphic to show for this state. A few graphics are installed together with the configuration software, others may be downloaded from the website or you may draw your own graphics as well.

NOTE: Almost any bitmap format like BMP, JPG, GIF, PNG and so on may be used. Vector graphics cannot be imported directly. Use the export function of your vector graphic software to generate a GIF, BMP or JPG file in a suitable pixel size first. Working with graphics is covered in a later section of the manual, explaining the workflow to design your own graphics in more detail.

Once you selected a bitmap file, the bitmap control will resize itself automatically to fit the selected icon. Repeat the process for the remaining states until all states have a bitmap assigned to them. Use different bitmaps, so that you can distinguish between the individual states. The size of the control will always be the width of the widest icon and the height of the tallest icon.

You can test the look of your bitmap control by selecting the individual states in the mapping table and watch the LCD preview. The state which is selected when you write the project to the device will become the default state of the control.

Step 7: Write the Project to the L-Vis device

Finally we are ready to write the project to the L-Vis device. Each project should also be saved in a file on the PC when you are done. Although it is possible to read the project back from the device, it should not be considered a 100% safe place for the project to be, since the device may erase the project in case it finds a severe error which would otherwise prevent it from booting up again. Also if the erase jumper is accidentally set, or the *Remove Configuration…* command is selected from the **File** menu, the project in the device may be lost. To save the project, select *Save as…* from the **File** menu and enter a project name. To write the project to the L-Vis device, press the button with the red down arrow in the toolbar and confirm the dialog.

NOTE: If you created static NVs, a warning message will appear, stating that the static interface of the device will change and that the software will need to adjust the definition of the device in the database. If you commissioned the device in the database already, make sure to download the project in plug-in mode. See the chapter about standard procedures for CEA709 devices for detailed information about this topic.

The project file is now written to the L-Vis device. After the L-Vis has rebooted, it shows the tutorial project on the display.

If the NVs were creates statically in the project, they should now be available on the device. You can now bind the output NV and the input NV together. In case of dynamic NVs, this was already done in step 2.

Step 8: Use the L-Vis

You should now be able to use the device to set the state and the value of the output switch NV and immediately see the results on the input NV, since the two were bound together in step 2.

To change the state, press the bitmap control. A dropdown list with the tree icons you assigned to the tree states in the mapping table will appear. Now select the desired icon to set the state.

NOTE: Whenever an element is selected from a dropdown list of icons or texts, the device will search the mapping table to find the value associated with the selected element. This value will then be assigned to the output data points which are connected to the control.

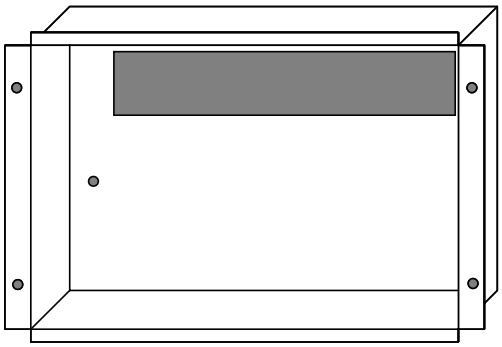
The new state will be sent out and will be received immediately by the input NV. The new state should now be displayed on the text control, using the texts which you specified in the mapping table.

To change the value, select the bar control and move the bar up and down. The current value will be sent out, received back in, and should be visible immediately on the numeric control.

Mechanical Installation

Dimensions and Mounting

The L-Vis enclosure consists of 2 parts. The frame should be mounted inside the wall or in a cabinet door. For wall mount and cabinet door mount a hole with 180 x 150 x 57mm should be made.



Display Mounting Box

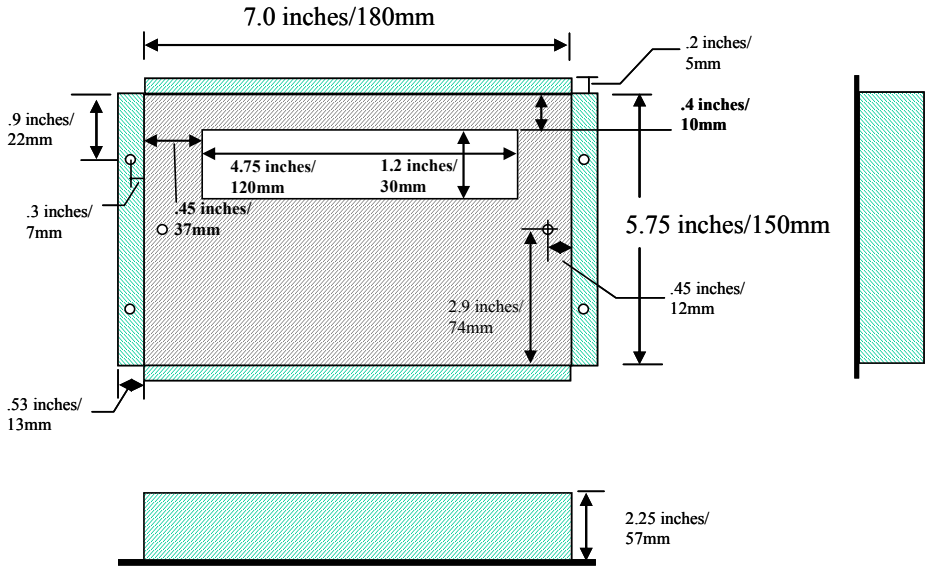
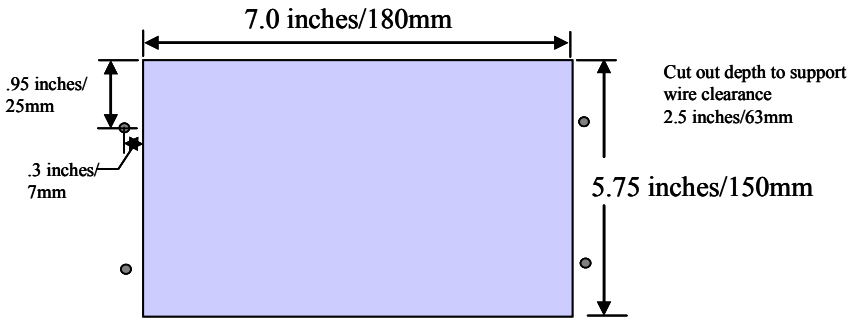


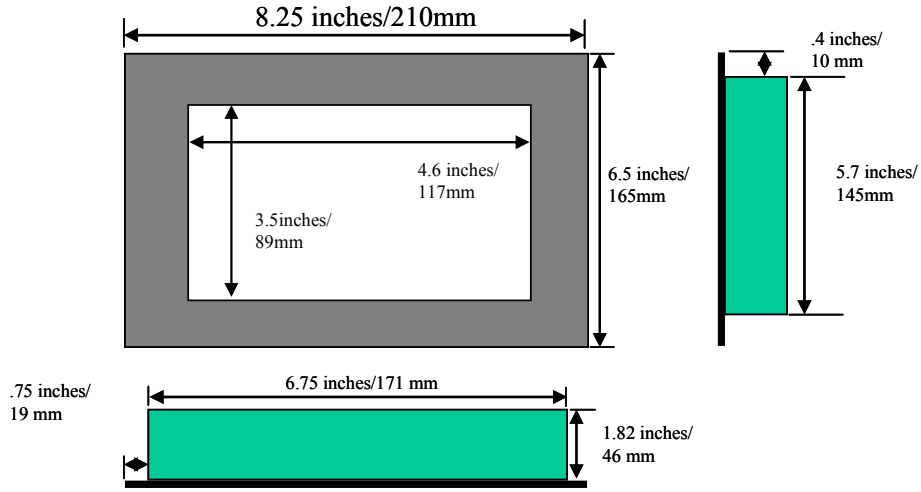
Figure 1 Hole dimensions for wall mount and cabin door mount.

For wall mount the frame should be mounted flush with the wall surface, for cabin door mount the frame can be attached to the cabin door with 4x M4 screws. Countersunk screws are preferred. The front panel has four recesses to burry the countersunk screw heads.

The L-Vis device slides right into the frame and the spring action of 8 springs holds the unit in place.



Wall Cut Out Hole



Front Display Panel

Figure 2: Display dimensions of L-Vis.

Theft Protection

To protect the L-Vis device, the device can be connected to the wall mount frame with the supplied chain as shown in Figure 3.

Figure 3: Connecting L-Vis to the wall mount frame.

Electrical Installation

Connection diagram

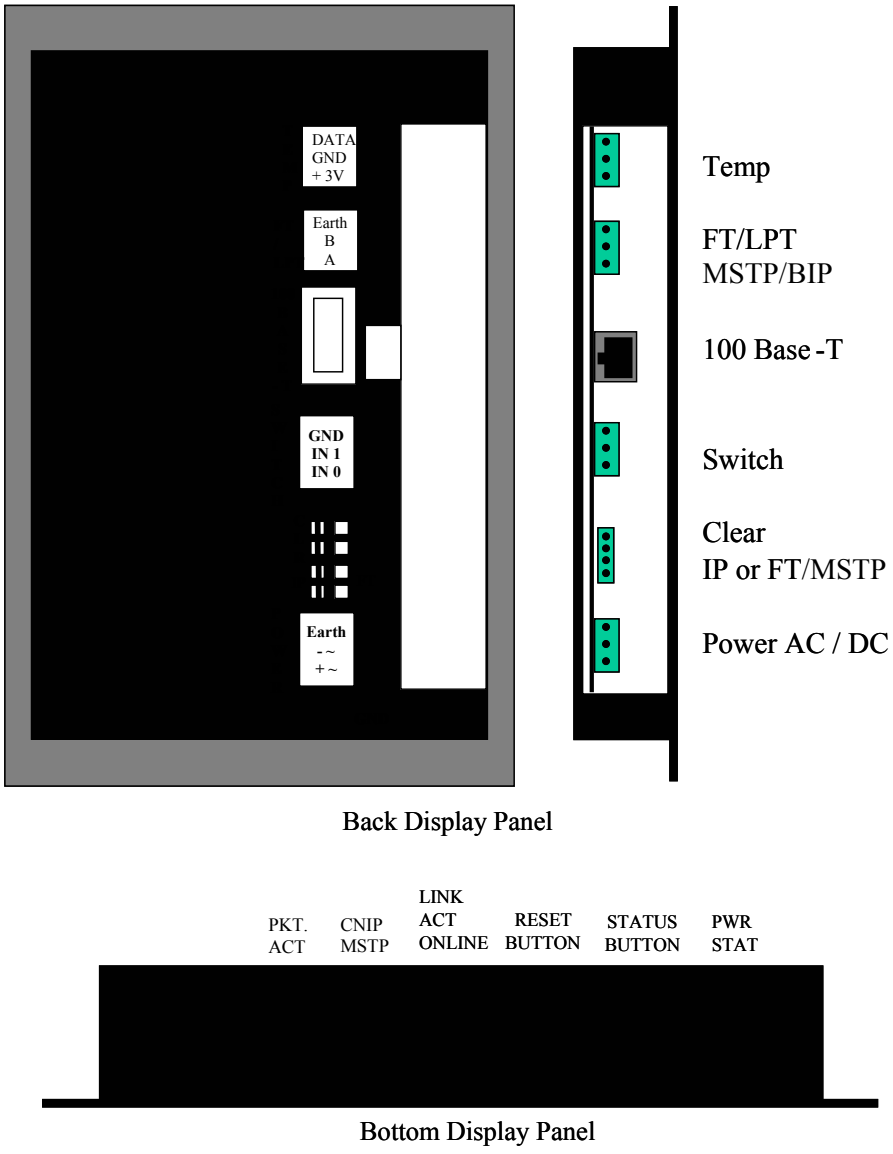


Figure 4:L-Vis connection diagram

Electrical Characteristics

The electrical characteristics are shown in the following Table 1.

Characteristics	Value
Operating voltage	24 VDC or 24 VAC ± 10%
Power consumption	8 W (backlight on), 3W (backlight off)
In-rush current	Up to 1000 mA @ 24 VAC
Operating temperature (ambient)	10°C to +40°C
Storage temperature	-10°C to +50°C
Humidity (non-condensing) operating	10 to 90 % RH @ 50°C
Humidity (non-condensing) storage	10 to 90 % RH @ 50°C
Switch input	Floating contact
Ethernet connection	100Base-T
CEA-709	FT-10/LPT-10
Enclosure	Stainless steel, anodized aluminum front panel E6C0
IP Code (IEC 60529)	Front: IP54 / Back: IP10
LCD display	320x240 pixels, 256 colors
LED backlight	CTFL backlight, 10000 hours / auto off
Installation	Wall mount

Table 1 Electrical characteristics.

Touch Panel Cleaning Instructions

Clean and soft clothes with neutral detergent or with ethanol may be used for cleaning. **Do not use any chemical solvent, acidic or alkali solution.**

Terminals and Jumpers

All connectors and configuration jumpers are accessible from the rear of the device. The following connectors are available:

LVIS-3E100: Select IP-852 or FT-10 channel first. LVIS-ME200: Select BIP or MSTP mode first.	The unit can be operated on an IP-852 (IP-10) channel as well as on an FT-10 or LPT-10 channel (BIP or MSTP for BACnet devices). The jumper labeled FT/IP or BIP/MSTP distinguishes between the 2 modes of operation. Please set Jumper in order to operate the device on an IP-852 or BIP channel (IP mode) and remove the Jumper in order to operate the device on an FT-10 / LPT-10 or MSTP channel.
Connect the Earth Ground wire to the earth ground stud.	Power is connected to the 3 position terminal labeled POWER. Please use only power supplies with the characteristics shown in Table 1. Connect earth ground to the stud labeled with the earth ground symbol. Loosen the top nut and attach the earth ground wire to this location.
FT-10, LPT-10 connection (LVIS-3E100)	The FT-10 or LP-10 network is connected to the terminal labeled FT/LPT. The signal wires are connected to terminals A and B, the shield if available is connected to terminal EARTH. This EARTH terminal is connected to the main

	earth terminal.
BACnet MSTP connection (LVIS-ME200)	When in MSTP mode, the RS485 bus is connected to the terminal labeled MSTP.
External temp sensor	Up to four external temperature sensors can be connected to the terminal labeled TEMP. Compatible temperature sensors are available from LOYTEC under the part number L-TEMP1. The temperature range of this electronic sensor specified as -55 to +125°C and the accuracy is +/-0.5°Celsius within the range from -10 to +85°C. The resolution of the sensor is 0.0625°C. The sensor device contains an integrated circuit which is connected via a digital interface to the main unit so that no further calibration is needed. Multiple sensor devices are connected in parallel (bus topology). The measured temperature is available in four internal system registers (*Sensor 1 Temp*. to *Sensor 4 Temp*.) where the sensors are assigned to the registers by increasing serial numbers of the sensor hardware. The terminal cannot be used for direct connection of passive NTC or PTC elements. DO NOT CONNECT ANY DEVICES OTHER THAN L-TEMP1 SENSORS to this terminal.
External switch inputs	Two external switches (push button or open-close) can be connected between terminals IN0 and GND as well as IN1 and GND on the connector labeled SWITCH. The status of the switches is available on the device in two system registers *Switch Input 1* and *Switch Input 2*. On the LVIS-3E100 device, IN0 is also used to control the integrated Lamp Actuator object which is always present as part of the static interface of the device.
TCP/IP connection	In case a CEA709 unit is connected to an IP-852 channel or a BACnet unit is connected via BACnet/IP, connect the Ethernet cable to the connector labeled 100Base-T. The device also accepts 10Base-T connections via this port.
CLEAR jumper	To remove the currently stored project from the device, set the jumper labeled CLEAR, disconnect power and connect power again. Wait until the unit has started and remove the jumper again.

LEDs and Buttons

All LEDs and buttons are accessible from the front and the bottom side of L-Vis. Please see the descriptions below for their functionality.

Status button	Pressing the Status button sends out a service pin message on the IP-852 or the FT-10/LPT-10 channel (CEA709 models) or send out an 'I Am' message (BACnet models). To remove the CEA709 network configuration (data which was stored on the device when it was commissioned), hold the service pin button pressed while the unit boots and release the button within 10s when instructed to do so by a message on the display.
Reset button	Behind the small hole next to the status button is the reset button. Use a pin to reach the reset button in order to hard-reset the device. Doing this may cause trend log data or other persistent data to be lost or reverted back to earlier data. To avoid data loss, reset the device via the configuration software or the setup menu (command page).
Power LED	The power LED lights up green as soon as power is connected.
Status LED	The status LED lights up red when the internal persistent

	storage device is accessed. Also, on CEA709 models operated on an FT-10/LPT-10 channel, this LED indicates the node status. The LED is off if the node is configured online and flashing red with a period of 1 Hz if the node is in the un-configured state.
ACT 709 LED ACT BAC LED	This LED indicates incoming and outgoing data packets on the currently active communications channel. Only packets which are addressed to the device are shown.
LINK Ethernet LED	The LINK ETH. LED indicates a successful Ethernet link.
ACT Ethernet LED	The ACT ETH LED shows activity on the Ethernet network.
ONLINE LED	The ONLINE LED lights-up green if the node is in the configured online state (CEA709 models only).
CNIP LED (LVIS-3E100)	This LED either shows the current status of the IP-852 interface (in IP-852 mode) or the status or the remote network interface, RNI (in FT-10 mode). IP-852: The LED lights green if the device is properly configured and member of an IP-852 channel. The LED lights orange when the device is configured in a channel but is waiting for updated channel information from the configuration server. In case of errors, the LED lights red. RNI: The LED is dark if RNI is not supported by this device (older devices do not have enough node IDs to support RNI). The LED is green if the remote network interface is ready for connections and orange if the device is currently in use. In case of errors, the LED is red.
MSTP LED (LVIS-ME200)	This LED shows the status of the MSTP interface, if the device is operating in BACnet/MSTP mode. The LED is green for normal operation, orange if there is no token and red if there are communication errors.

Interface Configuration

Selecting the Interface

Both the CEA709 units and the BACnet units have two network interfaces and two different types of communication going on, which should be clearly distinguished:

- Communications with the configuration software, to read and write configuration data, upgrade the firmware, and retrieve diagnostic data from the device (configuration).
- Communication with other devices on the control network, to send out new data the user entered through the device and to receive new data which is then displayed (operation).

One of the two interfaces is the IP interface (Ethernet 10/100Base-T) which is always available for configuration and may also be used for operation, although different protocols will be used for the two tasks as shown in the table below.

The second interface is a specialized control network interface, like FT-10 for the CEA709 devices and MSTP for the BACnet devices. Only the CEA709 models are currently able to use their control network interface for configuration as well. The BACnet models need the IP interface for configuration.

Model	Interface	Task	Protocol	IP Jumper
LVIS-3E100	10/100Base-T	Configuration	FTP	Any Pos.
		Operation	CEA852	SET
	FT-10	Configuration	CEA709	NOT SET
		Operation	CEA709	NOT SET
LVIS-ME200	10/100Base-T	Configuration	FTP	Any Pos.
		Operation	BIP	SET
	MSTP	Operation	MSTP	NOT SET

Table 2: Available interfaces

Configuring the IP-852 interface

Before the L-Vis device can be used on a IP-852 channel, the following things have to be configured in the Setup Menu of the device:

1. **IP Settings:** Configure the IP configuration of the L-Vis device. Enter the setup menu of the L-Vis and configure the IP-Address, Net mask and Standard Gateway. Reset the device when the IP configuration is finished.
2. **CEA852 configuration:** If required, set the Escrow time, Aggregation time and the MD5 key on the CEA852/RNI page of the setup menu. The CNIP port setting should normally be set to 1628 and the NAT mode should be set to automatic.
3. **Configuration Server:** Add the L-Vis device to an IP-852 channel. To do this, add the IP address of the L-Vis device to the channel list in a configuration server, e.g. on an L-IP, and restart the L-Vis device. L-Vis will then wait for the configuration server to contact it and provide the necessary channel information. If the device was a member of a different channel before, it will not wait an instead boot up with the already known channel information. The configuration server will then reconfigure the device to become part of the new channel.
4. **Check configuration server:** To check if the L-Vis device was correctly added to the channel, enter the CEA852/RNI page in the setup menu. The configuration server field should now display the IP address of the configuration server.

NOTE: During system start, when the device is used on an CEA852 channel for the first time, it waits for a configuration server to contact it within 30s. If this is not successful for 30 seconds, the device will switch back to CEA709 mode and boot up so that you may make modifications to your settings and try again. The same applies if DHCP was enabled and the unit is not able to get an IP address for 30 seconds.

Operating L-Vis

Touch Screen

Operation

This section describes how to operate the touch display of the L-Vis device. Most operations should be fairly intuitive, so that users of the device do not need to read a manual before they are able to operate the device.

L-Vis devices use a resistive touch screen. This type of screen can only detect one touch position at a time, that is, you cannot press two buttons at once. The screen delivers raw data which must be converted to LCD pixel positions before it can be used; therefore a touch screen of this type needs calibration. All devices come pre-calibrated from the factory and should be accurate enough to operate the device out of the box. To operate a device using very small control elements or from an unusual viewing angle, it may be necessary for the user to re-calibrate the screen, using the built-in calibration function which is available in the setup menu (section commands). The procedure is explained in more detail in the next section.

The touch pressure is currently not measured and has no effect on the operation.

The touch display is able to detect three different input actions::

- Touch (one point at a time)
- Touch and hold
- Touch and move

The simple and intuitive **touch** operation is used to select menus, select controls and enter data on the input keypad. This is straight forward.

The **touch and hold** operation opens the navigation menu after a configurable time (0 to 5 seconds). Please note that for correct operation, the touch and hold action should be executed on a free sport on the display. If the area of an input control is touched, the control enters input mode and all further input is processed by the control.

The **touch and move** operation can be used to adjust values on a bar graph control or move the cursor in a trend control. If executed in a free space on the page, there are tree touch gestures which the device can react to:

- **Touch and move up:** This will immediately bring up the navigation menu, so the user does not have to wait for the timeout, as is the case with the touch and hold action.
- **Touch and move right:** This switches to the next page connected to the currently selected menu item. If there is only one page connected, this gesture does nothing (it does not move forward to the next menu item).

- **Touch and move left:** As above, but switches to the previous page connected to the active menu item.

NOTE: Touch gestures may be disabled in the project configuration, in case the project uses a button-only navigation through the pages.

Calibration

In case the touch screen has to be re-calibrated, select the command *Calibrate Touch Screen* from the command dropdown list in the setup menu. This will show a black screen with a white cross at the top-left corner of the display. Touch the middle of the cross, using the same viewing angle and the same touch device (usually your index finger) as the user would during normal operation of the device. Once the touch is detected, the cross moves to the next corner. The procedure repeats until all four corners were measured.

Following the measurements is a verification pass. A white filled circle appears at the same locations as the cross. Again, touch inside the circle to let the device verify the data from the measurement pass. If the data is OK, the screen lights up green, if verification fails, the screen lights up red. The last position for verification is a circle in the middle of the screen, which must be touched as well for the calibration process to complete.

If the verification pass was successful, the new calibration data is stored in non-volatile memory so that it is retained across a power cycle or reboot.

NOTE: If you are unsure about the viewing angle at which the device will be used, it is best to calibrate for a direct front view, at a right angle to the display surface. This is the most likely position and will also provide enough margin for error in all possible directions. For normal control sizes, the small errors introduced by differing viewing angles are not noticeable

Data Input

As shown in the tutorial, L-Vis uses configurable control elements to display and input data. Whether a control is selectable for data input depends on the data points connected to it as well as on the current access level of the user:

- **Data Points:** If at least one output data point is connected to a control, the control becomes an input control, meaning the user may select the control and input new data, which is then assigned to all connected output data points, unless they are marked as *Constant Value*. If only input data points are connected, the control is not selectable and will only display the most recent value received from any of the connected input data points. Some controls, like trend log controls, may not be used to input new data but may still be selectable, to navigate through the recorded data.
- **Access Level:** If a control is an input control, it will only enter input mode if the current access level of the user is equal to or greater than the level defined for the control on the **Common Properties** page (option 'Access Level for Data Input'). To change the access level, a suitable PIN code must be written to the system register called *Pin Code Enter* (for normal login) or the new access level can be set directly by writing the register *Access Level*.

NOTE: It is valid to connect input and output data points to the same control at the same time. This is often done when the control should display the current state of a network value (for example the current light level) and also allow the

user to modify this value, using the current value as the starting point. The control will ignore any values coming in from the input data points while the user inputs data, so that incoming data does not interfere with the users actions, but resume displaying the incoming values when input mode is left.

If a control is selected, it enters a special input mode, in which all further touch actions are routed to and processed by the control. Depending on the control type, different data input methods are available:

- **Numeric Keypad:** For number controls and bar graph controls, a numeric keypad can be displayed when the input control is selected. New values can then be entered on this keypad, just like on a phone or a calculator.
- **Touch and move:** For bar graph controls, the bar may be directly moved to the desired position by touching the bar and moving it to the desired height. While doing this, the control can be instructed to send periodic updates to the connected output data points, so the user gets immediate feedback (useful for light control).
- **Drop down selection:** For text controls and bitmap controls, a drop down list is displayed when the input control is selected. The user can select the desired item from the list.
- **Push button mode:** For text controls and bitmap controls, a push button mode can be activated. This mode assigns a new value to a control whenever the control is selected. The next value is determined by selecting the next or previous entry in the mapping table, so the user may cycle through the available values.
- **Actions:** There is an indirect way of assigning values to output data points using the *Update Data Points* action. This is sometimes useful, for example to store a current value in a register data point when the user selects or touches a control. These actions are explained in more detail later on.

The control decides when to leave input mode. This is also called loosing the *Input Focus*, since the control returns input processing back to the page which is currently shown. Upon input focus loss, the control usually sends out the final value and stores it in non-volatile memory, so that it is retained across a power outage or reboot.

NOTE: The special persistent flag does not need to be set for these data points to retain their value. The control forces persistent data storage automatically.

Controls usually return the focus when you touch an area outside of the control or when you leave the device idle for a specified amount of time. Some controls (like the keypad) have OK and Esc buttons for you to press, to either close and accept the new value or close and restore the previous value.

Leaving a control idle while in input mode will usually be interpreted by the control as a *cancel* action. The control will then leave input mode, return the focus to the page and restore the value it had when input mode was entered.

The idle timeout can be set in the **Project Settings** dialog, together with a number of other timeout values.

Setup Menu

All devices come with a built-in setup menu, which is used to set device specific parameters, such as the devices IP address, control network settings, or date and

time zone. These settings are related to the installation of the device and are usually configured at installation time.

Once the device is installed and a project is downloaded to the device, the built-in setup menu may be hidden, so that it is no longer accessible to the users of the device. Alternatively, access to the setup pages may be protected by a PIN code. Both options are available in the **Project Settings** dialog, which can be accessed from the **File** menu in the configuration software.

The standard setup menu always contains the following pages:

- **TCP/IP:** On this page, the IP address, network mask, gateway, and optionally NTP server addresses for time synchronization can be configured. Alternatively, the device can be instructed to get the required settings from a DHCP server in the network (automatic IP configuration). Changes on this page will not be effective until the device is restarted.
- **Date/Time:** This page is used to set date and time, as well as the current time zone. Always adjust the time zone first and then set date and time to the local time. There are various ways to synchronize the time with external time sources. The current time source is defined by the loaded project and is displayed at the bottom of the page. If an external time source is used, only the time zone needs to be adjusted here.
- **Commands:** This page contains a dropdown list of the commands which can be executed. Some commands are available on all devices, while others are specific to a device family. The following commands are defined:

Command	Description
Send Service Pin Message	CEA709 models only. Send out a service pin message.
Un-configure Node	CEA709 models only. Set the device back to un-configured state (forget network address).
Clear System Log	Clear the system log of all entries.
Dump IP Statistics	Dump the current IP statistics to the system log, useful to debug IP connectivity problems.
Save All Trend Data	Save the data of all persistent trend logs right now (automatically done when a clean shutdown of the device is executed).
Lock Pages (Logout)	Consider all protected pages to be locked again, after the PIN code was entered and the pages were unlocked before. This basically sets the current access level back to zero.
Calibrate Touch Screen	Start the touch calibration routine.
Clear Data and Reset	Clear all persistent data (user data points forget their stored value).
Reset Device	Perform a clean shutdown and reboot. All persistent data will be saved before the device restarts.

- **About:** Show the about page (default title page).
- **Exit:** Exit the setup menu and return to the main menu.

The CEA709 models provide the following additional pages:

- **CEA709:** On this page, the device can be given a CEA709 address (domain/subnet/node) and can be set online. This is useful to

connect to the device in standalone mode, before the device is actually commissioned in a network, for example because the project needs to be downloaded first to define the static interface of the device and there is no TCP/IP connectivity available.

- **CEA852/RNI:** On this page, the IP-852 parameters or RNI parameters (depending on the mode of operation) can be specified. Supported parameters are the escrow and aggregation timeout, the IP-852 port number, the MD5 key, and the NAT support mode. Please refer to the documentation of your configuration server for more information about these parameters. The defaults should normally be OK, unless your channel uses MD5 encryption, in which case you need to enter the MD5 key and activate it by selecting *Enable with new key ->* from the dropdown list after the key was entered.

NOTE: The key is displayed as 8 groups of 4-digit hex values, which is a common representation of MD5 key values. The order to read the key is from left to right and top to bottom.

It is not possible to enter the configuration server or time server on the L-Vis device. Instead, the device must be added to the channel on your configuration server, which will then contact the device and set the channel-wide parameters such as the time server addresses automatically. The result is displayed at the bottom of the CEA852 setup page.

NOTE: For security reasons, enabling MD5 with a new key will store and activate the key and then reset the input fields to all 0000, so that the current key can not be seen on the display. Once the key is stored that way, it may be enabled and disabled using the dropdown, even though the input fields always show 0000. Consider these fields to be used for input of a **new** key only.

The BACnet models provide the following additional page:

- **BACnet:** On this page, the BACnet device ID, MSTP node address and baud rate (for MSTP mode only) and the BACnet/IP port number (for BACnet/IP mode only) can be set. The currently active interface is shown on the bottom of the page.

Custom Setup Menu

Starting with version 2.0 of the device firmware, the project may use standard controls on standard project pages to set all system parameters, like IP address, date, time zone and so on. To do this, create a suitable control and connect the system parameter which it should modify. This way, a project may provide a completely customized setup menu, matching the design of the other pages in the project, for example a localized Japanese setup menu may be provided, or a subset of the complete setup menu, such as specific commands from the command page, or the setup of date and time only.

NOTE: The example projects that are installed together with the configuration software include projects for the standard setup menu of the CEA709 and BACnet models. These projects should provide a good starting point for a customized setup menu.

Configuration Software GUI

Main Window

The main window of the configuration software (Figure 5) is divided up into 3 areas, as explained in step 3 of the tutorial.

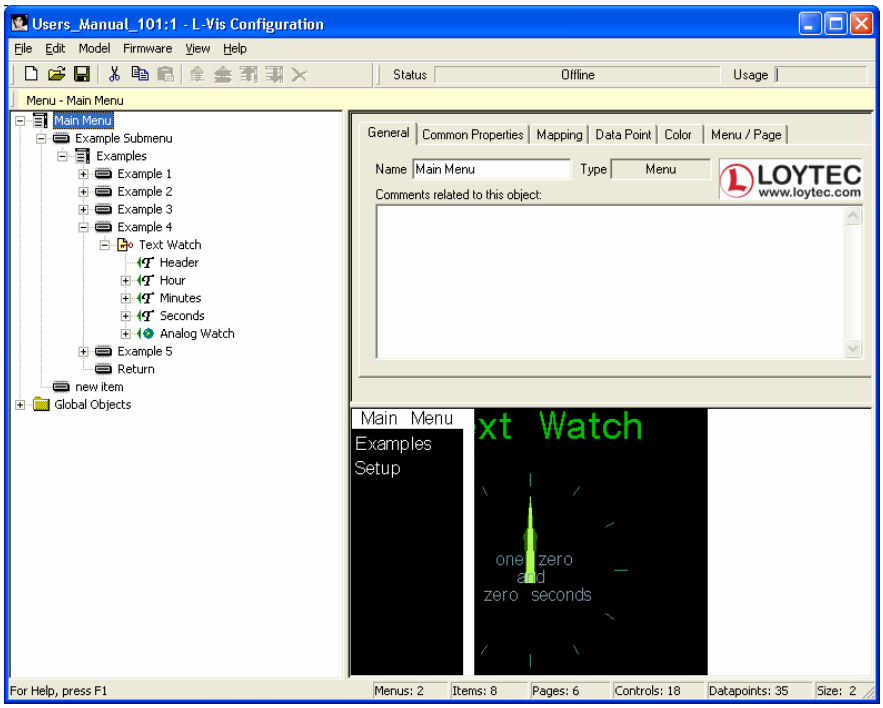


Figure 5: Main window of the L-Vis configuration software

Main Menus

Many of the items in the main windows menus do not require additional explanation, as they are commonly found in every PC software. Also, a short description of every menu item can be seen in the bottom left of the main window when moving the mouse over the menu item in question.

All items specific to this configuration software are referenced from the individual sections in this manual which explain the items function, that is, the function is explained and the menu item via which the function may be accessed is pointed out, not the other way around.

Workflow

Even though there are a lot of things to configure, creating a new project really is not that complicated. If this is your first attempt to create a project, it might help

to concentrate on one thing at a time to avoid unnecessary confusion caused by switching back and forth between objects and their different property pages.

A simple workflow is suggested below:

- First, build the desired object hierarchy using the tree view at the left. Use the context menus to add, cut, copy, and paste objects and use drag and drop inside the tree view to move existing objects around. It is also possible to have a second instance of the configuration software running and copy/paste objects between the projects. In the property view, keep the **General** property page open and enter names and descriptions for your objects as you create them. Do not get lost in detailed object configuration at this time!
- You should now have an object tree containing at least the hierarchy of menus, menu items, pages, and the basic controls which will be used to display and enter data. All objects should be clearly named. Now is a good time to go through the menus and configure their basic appearance. Select one menu at a time from the tree view and keep the **Common Properties** page open in the property view. For each selected menu, enter a menu title in the *Text* field and select the desired font.
- With the **Common Properties** still open, go through all menu item objects and enter each items text in the text field. Choosing a medium sized font, like the 12x16 ROM font, will make it easier to select the menu item on the touch screen. If the item text does not fit the width of the menu, don't worry about it for now. The required menu width will be set at a later step, when all menu items have their final text assigned. While you are at the common properties page, you may also load an icon for the menu item, which will be shown to the left of the item text.
- Go back once more to the menu objects of your project and open the **Menu/Page** property page. For each menu, set the *Container Width* such that the longest item text fits the menu. If your items use graphical icons as well, you may need to adjust the width reserved to the left of the item text such that the widest icon will fit. In case the menu contains more items than fit on the screen, make the scroll bar wider, so that the user may easily grab and drag it with the index finger. The default width of the scroll bar is designed to look good for menus which do not need a scroll bar.
- Now go through your pages and lay out the controls as desired. While a page is selected, go to the **Common Properties** page to select a background bitmap for the page, or go to the **Color** page to select a background color. That's all you should need to configure for the page itself at this time. Note that each page for which you set a full-page background image will require an additional 78kB of memory. To place small logos or page headers, use a bitmap control instead and select a suitable background color for the rest of the page. This will save a large amount of memory.
- As you lay out the controls, it is a good idea to also set their properties to modify their appearance, since this will ultimately change the size of the controls and may have an impact on their placement on the page. For text and bitmap controls, you should already have the data points connected and the mapping tables filled in, bar and trend controls should have their final settings of scale, tick marks and value range. The individual property pages are discussed in more detail below.

- Add actions, alarm generators, mathematical objects, and other global objects you require to put functionality into your project.
- Fine-tune colors and transparency on the **Color** page and layering by using drag and drop in the tree view.

This is of course not a complete list of things to do, but should give you an idea where to start from a blank project.

If objects or complete pages are copied from one project to another project, the copied objects may contain references to data points or loaded fonts which do not yet exist in the target project. If possible, any missing data points or fonts will be created automatically in the destination project. If this is not possible, for example if an object references a data point from a foreign technology (copy from a BACnet project into a CEA709 project), these references will be lost.

Common Property Pages

The individual property pages visible in the property view will change according to the currently selected object. Most property pages are directly related to a certain type of object and will be discussed together with the object itself. Some pages are used to set common properties and remain visible all the time. These common pages are explained below:

General

This is the page which should be open while creating new objects in the tree view. As you create new objects, give them a suitable name here, to clearly identify them in the tree view.

NOTE: The object name specified here has nothing to do with the appearance of the object on the device, if it is a visible object at all. The name on this page is just the name of the object in the object hierarchy. The name should be chosen such that looking at the tree view is enough to understand what an object is for.

The large area below the name field can be used freely to enter any description which might be needed for other people to understand what this object does, why it is here, how it works, and so on. This can be used to store the projects documentation together with the project, improving reusability and maintainability, in case the project is taken over by another person later on.

Additional information shown on this page is the unique ID of the object as well as the estimated memory usage on the target device.

NOTE: The unique ID of the object is used for identification. If the object records data which is stored in a file (trend log or data log), the file name will include this ID in order to match the data files to the respective controls. The UID is also used to reference other pages in the project (action *Show Page*).

Common Properties

The **Text** field is used to configure the textual part of an object. This may be just ordinary text or a format string, instructing the object how to format its text output. For menus and items, this field holds the menu or item title as it appears on the device, for controls which display text or a numbers (text, numeric, and date controls) this field contains a C style format string. The **alignment buttons** allow to adjust the alignment of the text inside the display box (left, middle, or right aligned). The **font window** is used to select the font for the text. If other than the built-in fonts are needed, additional fonts can be loaded into the project

using the **Load** button. Unused fonts can be removed from the device via the **Unload** button.

Object Type	Usage of the Text field
Menu	Directly used for the menu title.
Menu Item	Directly used for the menu item text.
Text Control	Format string which may contain one %s placeholder, which will be replaced by a string taken from a mapping table or a connected string data point. For static texts, use a text control and fill in the static text in the text field, without using a %s placeholder. The %s placeholder conforms to standard C rules and may include additional format modifiers between the % and the s: • **<number>** A number following the % sign forces a field with for the string of at least the given amount of characters. If the string is shorter, it is padded with white space at the left (right justified within the given field). • **-** A dash preceding the field width means the string should be left-justified inside the field (padded to the right). • **.<number>** A decimal point followed by a number is interpreted as the maximum length of the resulting string.
Numeric Control	Format string which may contain one placeholder for a floating point value, for example %f, %g,, or %e. To display a hexadecimal value, the placeholder %x may be used together with the option *Convert Data Point Value to Integer* which is available on the **Numeric Control** property page (detailed below). There are a number of format modifiers available for the expert user to tailor the output of the numeric control. Novice users may use the format string wizard on the **Numeric Control** property page to construct a suitable format string without knowledge of the details.
Date Control	Date/Time format string which may contain a number of different placeholders to display date and time in textual form. The format string conforms to the ANSI C strftime() function and is detailed in the appendix of this document. On the property page of the **Date/Time Control**, a format string wizard is available for the user to create a correct date/time format string without knowledge of the details. Expert users may also look up the available placeholders in a C programmers manual for the strftime() function.

Also available on the common properties page are fields to enter the screen **position and size** of the selected object, if the object is a control. However, position and size of controls are usually modified directly in the LCD preview using the mouse or the cursor keys. For more information about position and size of controls please see step 5 of the tutorial.

The checkbox **Auto-Resize** is normally turned on, so that controls which support it will resize themselves automatically to accommodate the largest content they need to display according to the elements in the mapping table. The checkbox may be turned off for text controls to prevent automatic resizing and set the desired size manually.

NOTE: Manual size for text controls is most often used when the selection area should be larger than the longest text. In this case, the text is often also center-aligned, using the buttons to the right of the text input field. Another case is text received from the network. In this case, the configuration software does not now the size of the longest text at configuration time, therefore the user needs to reserve a suitable size for the text manually.

Below the screen coordinate section is an area where a bitmap can be loaded. A number of graphic formats are supported, for example BMP, JPG, PNG, TIFF

and others. Not supported are any vector formats. They need to be exported to a bitmap format first.

When a 256-color GIF or PNG image is loaded (indexed color format), the configuration software does not change the color indices of the loaded pixels, that is, the color palette of such an image should match the VGA palette. If you are unsure or get false colors when loading such an image, save the image in true color format and let the configuration software do the color conversion/dithering as required. Graphics import is discussed in detail in a later section.

Depending on the object type, the image is used according to the following table:

Object Type	Bitmap is used for…
Page	Page background. The loaded bitmap should match the screen resolution of 320x240 pixels. Smaller background pictures are placed in the top left corner of the display. For example a 320x20 bitmap would appear as a page header, while an 80x240 bitmap would appear as a vertical bar at the left. Please note that a page requires an additional 78kB of memory as soon as a background bitmap is loaded, independent of the bitmap size. To place smaller static bitmaps anywhere on a page, use a bitmap control and assign the bitmap to the control instead of the page, then move the control to the position where the graphic should be located.
Bitmap Control	Bitmap to show when the control is created. If the control does not have a mapping table attached to it, this is the only image which is shown by the control. It is then similar to a text control containing static text. Bitmap controls may be used in this way to place logos or other graphic elements anywhere on the screen. If a mapping table and a data point is attached to the control, the images from the mapping table may replace the image specified here, when new values are received or selected by the user.

On the right side of the property page, the **access level** required for data input can be specified if the selected object is an input control. The access level must be equal to or higher than the level specified here, otherwise the user will see the control but will not be able to select it and input new data.

The button called **Set as Default** may be used to save the design of the currently selected visible object as the default design for new objects of the same type. If a number of similar objects is to be created, configure the first object, press the default button and then create the other objects.

NOTE: The set defaults are saved together with the project, so that the same defaults apply the next time this project is loaded. To change the defaults for an object, change the design as needed and press the default button again to update the stored default settings.

Color

The color property page is used to configure color and transparency for all visible objects. To avoid different color property pages for every object, the colors are set through this common page, using common names for the different colors. Not all objects support all colors. When an object is selected, it will report its color configuration on this page and set all unsupported colors to *unset* (black cross). To change a color, click on the corresponding color button and select the new color from the dialog.

NOTE: Most colors are named such that it is clear to which element of an object the color applies, like Text, Background, Selection and similar. Colors which need more explanation are the three line colors. How the available line colors are used by a particular object can be found in the objects documentation.

The right side of the color page allows to set the current color scheme for multiple objects at once. Applying a color scheme to multiple object means that all colors which are *set* in the color scheme will be changed in the object, if the object supports this particular color, while all colors which are *unset* in the color scheme will remain unchanged.

NOTE: This allows to change individual colors and keep others as they were, for example you may change the background of all controls on a page without changing any of the other colors

There are two modes of operation available right now:

- **Apply to all sub-objects:** This mode will apply the color scheme to all sub-objects of the currently selected object. This is used to control the color design of the whole project (root menu selected) or individual pages (a page selected).
- **Apply to all objects of this type:** This mode will search all objects of the same type as the currently selected object, on the same hierarchy level, for example if you select an item of a menu and use this mode, you can change the colors of all items in THIS menu, without affecting other menus. If you select a text control on a page, you can use this mode to change the color of all text controls on THIS page, and so on.

Object Description

Introduction

Every L-Vis project is built using a number of different objects. Each of the objects has a relatively simple function. To build a complex project, the simple objects are put together and organized in an object tree, which is shown in the tree view of the configuration software.

Interactions between the objects are defined by their location in this object tree, for example, a menu item object will always display a menu item on the device, but it depends on the location of the object in the tree in which menu and at which position in the menu the item appears.

There are objects to represent menus, menu items, pages, various types of controls to display and input data, there are objects to perform mathematical operations on data, or generate alarms. The total number of different object types is kept to a minimum and the objects are designed as generic as possible, to ensure a steep learning curve and allow flexible and creative use of the available objects as the building blocks of more complex applications.

When building the object tree, there are certain limitations in how objects can be connected to each other. Most of the time, this will be clear from the context, for example it is clear that you cannot connect a page object to a menu, since a menu would not know what to do with a page. A menu is used to manage a list of menu items from which the user may choose. Therefore, a menu object will only accept menu item objects as child objects. A page object can then be attached to a menu item object, causing the item to show the attached page, when it is selected from the menu.

NOTE: Such limits are enforced by the configuration software automatically, so you cannot drop or paste objects into places where they have no meaning.

Some objects may be connected to a number of other objects, for example a data point may be connected to all kinds of controls, but a trend control only accepts input data points, not output data points. Mapping table objects may be connected to text, bitmap, number, and bar controls, but not trend or date controls, and so on. Using the context menu of an existing object to create a new object automatically will show only the kind of objects which can be attached to the existing object, so there is no room for error.

A typical object hierarchy which shows the most important relationships between the available objects is shown in Figure 6.

The individual objects are explained in more detail in the following sections.

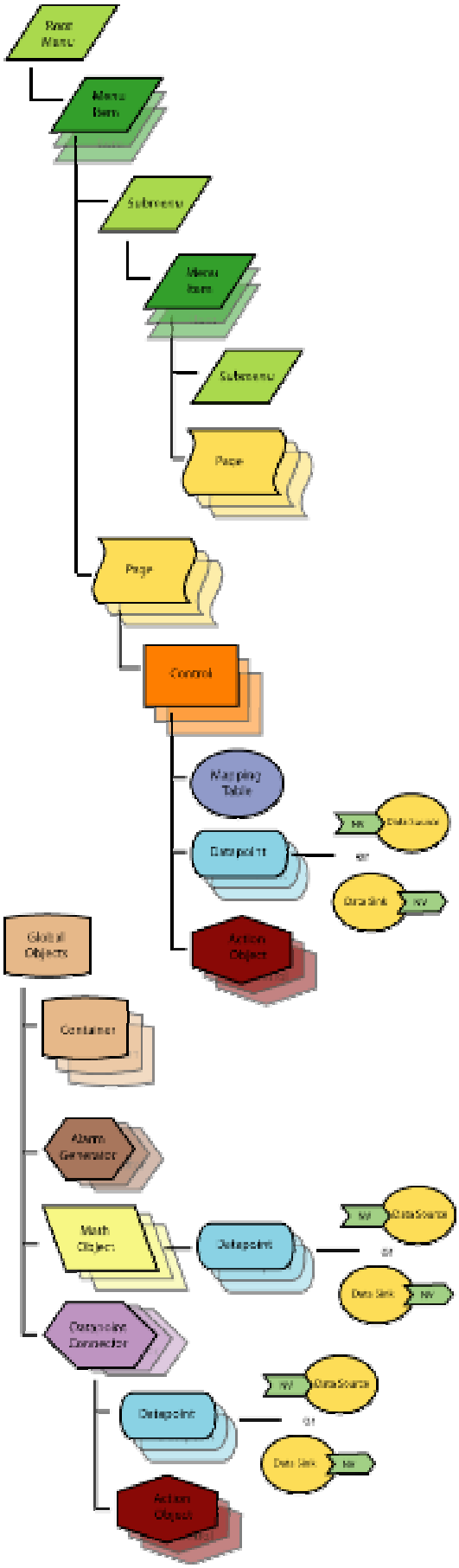


Figure 6: L-Vis Object Hierarchy

Menu

A menu object is used to manage a collection of menu item objects. On the device, a menu is a window which opens on the left side of the display and shows the items which are contained in the menu. The menu can handle more items than fit on the screen. If this is the case, a scroll bar is provided for the user to move the contents of the menu up and down to see the hidden items.

NOTE: Every project always has a menu object as the top level object. This is called the root menu. It must always be there and it cannot be deleted. However, you may adjust its properties just like any other menu.

Apart from the root menu, the only other places where menu objects may be created are as child objects of menu items. If a menu object is connected to a menu item, selecting the item will show the connected menu. This is called a sub-menu. To navigate back from the sub-menu to the parent menu, the sub-menu must contain a return item, which is a menu item object which has no further objects connected to it (no page and no sub-menu to show).

Menu Properties

A menu consists of a frame and an area containing the menu items. The frame includes the menu title and the scroll bar, whereas the item container is the inside space of the menu, where the menu items are shown. The assignment of colors on the **Color** property page to parts of the menu can be seen in the following table.

Color Name	Element to which the color applies
Text	Menu title text.
Frame/Axis	Title background and the frame around the scroll bar.
Bar/Bitmap	Scroll bar.
Container	Scroll bar container background.
Background	Background of the menu item area. The background of a menu cannot be set to be transparent.

On the **Menu/Page** property page, the width of the menu item area and the scroll bar can be entered. The value is specified in LCD pixel (the full screen width being 320 pixels). The *Bitmap Width* parameter specifies how much space for icons to the left of the menu item text should be reserved, if an item uses a bitmap. This is used to have a vertically aligned text column, even when the icons of individual items do not have the same width.

NOTE: Even though the bitmap width parameter changes the appearance of menu items, it is a property of the menu because it is the same for all items which are shown in this menu. Moving an item to a different menu will show the item according to the bitmap with rule of the new menu.

Menu Item

Menu item objects are used to build the contents of a menu. They are shown in the menu in the order in which they appear in the object tree. On the device, each menu item becomes a selectable area of the menu, which the user may select to open the page or the sub-menu associated with the item.

Each item object can hold zero or more page objects and zero or one menu object, as shown in the object hierarchy diagram. It depends on the connected objects, what will happen when the user selects the menu item.

Pages	Menu	Function
None	None	This item is a **return item**. When the user selects it, the current menu will close and the parent menu will open.
1	None	A **standard item**. Upon selection, the menu will close and the page will be shown.
> 1	None	A **multi-page item**. Upon selection, the menu will close and the page which was up when the item was active the last time will be shown (the first page, if this is the first time the item is selected). The page flip actions, touch gestures, and page timeouts apply.
None	Yes	A **sub-menu item**. Upon selection, the connected sub-menu will be shown for further navigation.
1 or more	Yes	A **combined item**. The connected page(s) will be shown in the background, while the connected menu will open in the foreground for further navigation. This type of item can be confusing for the user and should be used with care.

Always add a return item as the last item of your sub-menu, or the user will not be able to navigate back.

In the root menu, a return item is used in a different way. If a return item is found in the root menu, the device will use it to connect the system setup sub-menu to it, making it the setup menu item. This is done so that the user may provide a menu item for the built-in setup menu and configure it through the normal configuration software, just like any other menu item.

NOTE: If the project does not provide a return item as the last item of the root menu and the built-in setup menu was not disabled in the project settings, a default setup menu item will be created automatically. However, this item will most likely not fit the design of the other items in your root menu, so it is a good idea to always provide this item in your project.

Menu Item Properties

On the **Common Properties** page, a menu item can be assigned a text as well as an icon bitmap. Obviously, at least one of them should be set to make a usable menu item. If both icon and text are set, the icon will appear on the left side, the text on the right side. If the icon is smaller than the reserved bitmap width of the menu, the icon will be centered inside the bitmap width.

On the **Color** property page, the following colors can be set for the menu item:

Color Name	Element to which the color applies
Text	Menu item text.
Selection	Frame drawn around the selected item.
Bar/Bitmap	Color of a monochrome bitmap.
Background	Color of the bitmaps background. This will be the color which is shown transparent in the items bitmap. The background of a menu item is always set to transparent mode.

Page

Page objects are simple objects to organize the control elements which are visible on the device. When a page object is connected to a menu item and the item is selected from the menu, the page and all the controls on it will be shown on the display. Previously visible controls will be hidden, but will continue to exist on the device (so that a trend control may continue to record data, for example). Technically, the function of a page therefore is to group a number of controls together to show or hide them all at the same time.

Page Properties

On the **Common Properties** page, a bitmap for the page background may be specified. Such a bitmap should match the dimensions of the page, which is 320x240 pixels on current models. For a single-color background, select the desired color on the **Color** property page.

All other properties of a page object are set on the **Menu / Page** property page.

On this page, the following settings are available:

- *View Timeout*: If this timeout is not zero, and there is no user input for the specified amount of time, the system automatically switches to the next page (provided there is more than one page connected to the same menu item). After the last page was shown, the procedure is restarted from the first page.
- *Page Access:* This defines the minimum access level required to view the page if it is marked as locked/protected (see below).
- *Locked Page*: If this flag is set, the page may only be displayed if the current access level is equal to or higher than the level specified for this page (see above). If the access level is not sufficient, a suitable PIN code must be entered.
- *Invisible Page* allows hiding the page on the device, which means that it will not be accessible for the user until this flag is removed. However, the controls on a hidden page work as usual, for example a trend control placed on such a page will still be recording trend data. A hidden page may also be used as the target of a show page action, so that the page may only be visited through this action and not directly via the menu.
- The *Default Page* flag marks a page as the default page of the device. The default page is displayed after a configurable amount of idle time and when the device is started.

Controls

All objects which can be displayed on a page are called **controls**. This is because they are usually used to provide to user with an interface to control a data point value or trigger actions. Controls are also used to display the current value of a data point and sometimes even display just static content, to enhance the visual appearance of a page.

NOTE: There are other objects which are used to control or process data point values and which are not documented in this section, for example mathematical objects or alarm generators. These objects are not control objects, because they do not provide a user interface. They have no position and size coordinates or other visual properties.

Depending on the data point objects connected to the control, the control will either show static content only, show dynamic content based on values which are received from connected input data points, or become selectable and accept new values from the user, which are then written to the connected output data points. Controls which accept user input are called input controls.

The following sections describe each of the available controls and their properties.

Text Control

Text controls are used to display one or more lines of text. The text is entered on the **Common Properties** page in the *Text* area, as explained in the section about the common property pages. Dynamic text from a mapping table or from a connected string data point may be inserted at the %s placeholder, otherwise the text remains static.

On the **Color** property page, the following colors can be set for the control:

Color Name	Element to which the color applies
Text	Text color. This color may be overridden by color specifications from a connected mapping table.
Selection	Frame drawn around the text, if the control is selected. Also used to draw the grid of the drop-down list, from which a new text element is chosen (input controls only).
Background	Color of the controls background. The background of a text control may be set to transparent using the check box next to the background color button.

If the text control is an input control, it may be selected by a touch on the controls text field. A dropdown list will appear, containing all entries of the mapping table which is connected to the control. From this list, the user may select a new entry. The value which is associated with this entry in the mapping table will then be assigned to all connected non-constant output data points.

Instead of opening a dropdown list, text controls may also be used as push buttons, where each press of the button will change the value. This push button mode can be enabled on the **Text / Bitmap** property page, which is explained below, since it works the same for text and bitmap controls.

Bitmap Control

Bitmap controls are very similar to text controls, only that they display graphic elements instead of text. Otherwise the same behavior applies for input controls.

A static bitmap may be set on the **Common Properties** page, which is shown when no mapping table is attached to the control or no value was set or received, so the control does not know which entry from the mapping table to choose.

The bitmap control will automatically adjust and fix its size according to the loaded bitmaps. If there is no bitmap to display, the size can be set manually and the bitmap controls area will be empty, with just a frame drawn around it in the selected frame color.

NOTE: Bitmap controls without any bitmap and with the frame color set to the transparent background color are often used to define clickable areas on a page which uses a background graphic. In this case, the pages background already provides the graphic representation of buttons, lamps, building floors, or other elements, which should be selectable by the user. Using empty transparent bitmap controls, rectangular regions may be defined on the page, which the user

may select. The control itself usually has an action connected to it, to jump to a new page or update a data point.

The following colors may be set for bitmap controls on the **Color** property page:

Color Name	Element to which the color applies
Bar / Bitmap	Color of the frame which is drawn if no bitmap was assigned, or color in which a monochrome bitmap is drawn. May be overridden by colors from the mapping table. For color bitmaps, this color definition is ignored.
Selection	Frame drawn around the text, if the control is selected. Also used to draw the grid of the drop-down list, from which a new text element is chosen (input controls only).
Background	Color of the controls background, if no bitmap is shown. Otherwise this is the color which should be considered the background of the graphic. If the transparent check box is set, all pixels using this color will be transparent.

NOTE: In the VGA palette, there is one color (middle grey) defined at two different color indices (index 7 and index 248), meaning that this color appears twice in the palette. Graphic elements using transparency may use one of the two colors (248) to fill all areas which should later be transparent and still have the same color available for use in the bitmap (7). If you use any other color, for example black at index 0, you can no longer have black pixels in your graphic, since all pixels drawn with this color will be transparent, so you loose a color.

Push Button

Push buttons are not provided as a specialized control object type, but are implemented by a special mode of operation, which can be activated for text controls and for bitmap controls, to create push buttons showing text or graphic elements using all the features of these controls.

Push button mode is activated on the **Text / Bitmap** property page using the *Enable Push Button Mode* check box. Once enabled, the mode of operation is selected on the right via three radio buttons. The options are:

- **Send current value:** In this mode, each press of the button will cause all connected output data points to be updated with the current value of the control. The current value is defined by the last value received from any of the connected controls.
- **Select and send next value:** This mode will instruct the control to find the entry in the mapping table which corresponds to the current value of the control and then select the next entry to determine the new value which is sent out.
- **Select and send previous value:** Similar to the above mode, but the previous entry in the mapping table is selected to determine the next value.

Below the radio buttons is a check box, which, when checked, causes the control to change direction when either the end of the mapping table is reached, that is, it switches back and forth between mode 2 and 3, walking through all available entries in the mapping table (up and down).

NOTE: Obviously, mode 2 and 3 only make sense if a mapping table is attached to the control and the table contains at least two entries. A typical use is a table with two entries and the control in mode 2, with direction change enabled. This provides a simple ON/OFF toggle button. To build a push button which only

sends out a fixed value when selected, no mapping table is required. Set up the control using static properties and connect the output data point which should be updated with a certain value. Mark the data point to be *Constant Value* and enter the desired value as the *Default Value* of the data point.

Numeric Control

These controls are used to display values as numbers. Most properties can be set on the **Common Properties** page, as described earlier in this document. Similar to text controls, the color of the number, the background, and the selection frame can be set on the **Color** property page.

The **Numeric Control** property page provides access to the specialized properties of numeric controls, like the allowed value range and a wizard to generate a suitable format string for your control, if you don't want to enter it yourself on the common properties page.

The allowed *Value Range* is only enforced when the control is an input control and the user inputs new data. Values received from input data points are always displayed, even if they are outside the allowed value range, that is, the range is an input value range only.

The *Input Resolution* and *Acceleration* settings are only used by the older LVIS-3ECTB model, which has a jog dial instead of a touch screen. The settings define the amount which is added or subtracted with each turn of the jog dial and how the dial speed increases this amount.

The check box *Convert Data Point Value to Integer* needs to be checked, when you want to use an integer format specifier in the format string, like %x or %d. If the format string wizard is used to generate the format string, this check box is also controlled by the wizard as required.

The check box *Hexadecimal Input Keypad* can be used together with a %x format to provide a hexadecimal input keypad matching the way the value is displayed. It would be confusing to enter a decimal value and then see it converted into hexadecimal on the control, so the display format and the input keypad should use the same number system.

The check box *Password Input Keypad* may be used to enter a PIN code. The keypad starts out empty instead of showing the current control value and for each digit entered it only shows an star (*).

NOTE: It is possible to add static text around the value defined by the format string. If you generate the format string using the wizard, first generate the format string and then switch to the common properties page and add the static text before and after the format specifier in the text field. Any text can be entered, with the exception of the percent sign, since this character starts a format specifier. **To output a percent sign, enter %% in the format string.**

Bar Control

Bar controls are one of the more complex and versatile control types. In combination with other controls, they can be used for a large number of applications which are not immediately obvious, such as a moving sunblind or an arbitrary area on the screen which can be filled with a variable color (useful to mark open windows in a building, for example).

The basic application of a bar control uses a scale on one side of the bar, including tick marks. If the value represents a temperature, a small dot is sometimes included at the lower end of the bar, to make it look like a

thermometer. In this configuration, the bar control consists of the following elements:

- **Scale:** The numbers on one side of the bar, which are evenly spaced out and calculated to be easy to read. While resizing the bar in the LCD preview, the scale is constantly updated to show the most suitable scale for the given value range and size.
- **Tick Marks:** These are the small indicators next to the bar. They are calculated automatically to be evenly spaced out while representing a round step value between two tick marks. If the scale is disabled, the tick marks may be much closer to each other.
- **Dot:** At the lower end of the bar, a dot symbolizes a thermometer.
- **Frame:** The actual bar which displays the current value has a one pixel wide frame around it.
- **Bar:** Inside the frame is the bar which actually shows the current value. With increasing values, the bar moves up or to the right.

Position and size of a bar control, as defined on the common properties page, correspond to the frame of the bar control, as described above. It does not correspond to the selection frame drawn around the whole bar control.

NOTE: To move a bar control in the LCD preview, you must grab it somewhere inside the bar frame, not outside, like the scale or tick marks. To resize the bar, click on the lower right corner of the bar frame.

On the **Common Properties** page, a font may be selected to be used for the scale. Color configuration is done as usual on the **Color** property page. The following colors are supported by bar controls:

Color Name	Element to which the color applies
Text	Numbers of the scale.
Selection	Frame drawn around the entire control, if the control is selected.
Frame / Axis	Tick marks and the bar frame, as described above.
Bar / Bitmap	Bar which represents the value. This color may be overridden by color specifications from a connected mapping table.
Container	Empty space inside the bar frame, which is currently not filled by the bar color.
Background	Color of the background outside the bar frame. If the transparent check box is set, all pixels using this color will be transparent.

All other properties are set on the **Bar Graph** property page.

The most important property on this page is the *Value Range* of the bar. It must be adjusted to match the actual value range you want to visualize. If the bar is used to input values, this range also defines what the user may enter. Values outside the given value range cannot be entered, even using the key pad, which is optionally available for input bar controls.

NOTE: Set the desired value range, before you determine size and position of the bar, especially if tick marks and/or a scale is to be drawn. This is important since the scale which best fits the current size will be determined and drawn as you resize the control. Depending on the value range, the space requirement of the scale and the optimum size of the bar will vary.

The Flags below the value range control which components are drawn and how they are drawn. The flags are pretty self-explanatory if you consider the naming of the individual components of the control as outlined above. The flag *Numeric*

Input Panel enables the display of the numeric keypad when the bar enters input mode. It is then possible to either drag the bar as usual or enter an exact value on the keypad. The keypad will be positioned on the screen so as to not overlap with the bar, if at all possible.

NOTE: As you may have noticed, not all of the bar controls elements can actually be disabled. In particular, there is no flag to disable the bar frame. If the bar graph is used in an application where the frame is not wanted, it can still be made invisible. Select the same color for the bar frame as you selected for the background and check the *Transparent* box. The frame will now be transparent.

Special Application Hints

A powerful way to use bar controls is provided by colors and transparency. By disabling all the decoration around the actual bar, it is possible to have a rectangular area on the screen, which can be filled with a color or made transparent, depending on the value of a data point. This provides an easy way to selectively hide certain areas of the screen.

Example 1: Define a solid color for the bar and the transparent background color for the container and the frame. Now you can prepare a page background, showing a sunblind which is completely rolled down. Place the bar in front of this image and you are able to cover up parts of the sunblind with the solid bar color, making it look like the sunblind is going up and down. If you switch color assignments, you can use the moving bar to selectively *uncover* parts of the background.

Example 2: In front of the above window showing the moving sunblind, a completely transparent bar control may be placed (both bar color and container color are set to the transparent background). By connecting an output data point to this control, it becomes selectable and accepts user input. Now the user may touch any position on the window, which will result in a value update on the output data point. This value may now be used as a position indicator and the sunblind may be moved to the indicated position automatically, without the user keeping a down or up button pressed all the time.

NOTE: The static sunblind image in the background may be replaced by a bitmap control with a mapping table to show the current rotation of the sunblind.

Trend Control

Trend controls record and display data point values over time. This type of control does not allow inputting new values and therefore can not handle output data points. Only input data points may be connected to a trend control.

On the device, the control shows a graph with the value on the vertical axis and time on the horizontal axis. The time axis shows the amount of time which has passed since now, where the rightmost end of the axis represents the present time, with older data to the left (for example 10 minutes ago, 20 minutes ago, and so on). As time passes, the recorded data moves to the left and new data is added to the right. The smaller the time span on the time axis, the faster the curve moves to the left. When setting the time span, the resulting interval between two shift operations is calculated and shown on the property page.

The control is able to display three curves per connected data point: the minimum value, maximum value, and average value. To do this, the control records all incoming value updates between two shift operations. From this data, it calculates the minimum value, the maximum value, and a time weighted average value and adds this data to the right end of each curve.

NOTE: The average value calculated during each shift interval is the time weighted average of all input values received during that time frame. For example, if the input has a value of 0 for the duration of 9 seconds and a value of 20 for the duration of 1 second, the time weighted average value for these 10 seconds will be 2, because (0*9s + 20*1s) / 10s = 2. In contrast, the time independent arithmetic average value would be 10 (0+20)/2.

The scale labels and tick marks, if enabled, are automatically calculated and laid out. If the page background already provides a graphic representation of the scale and the control is only used to fill in the data, the scale and tick marks may be disabled. The best way to lay out the control is to first enable all required decorations (scale, ticks, and grid) and then change the size and position of the control to fit the scale.

Regarding color, the trend control is one of the most complex controls to configure, since it supports a large number of colors. The following colors may be set for trend controls on the **Color** property page:

Color Name	Element to which the color applies
Text	Numbers of the value scale and the time scale.
Line1	Horizontal grid lines (if the grid is enabled).
Line2	Vertical primary grid lines (if the grid is enabled).
Line3	Vertical secondary grid lines (if the grid is enabled).
Selection	Frame drawn around the entire control, if the control is selected.
Frame / Axis	Tick marks and axis for value and time.
Container	Background of the graph area, which is the rectangular area spawned by the value and time axis.
Background	Color of the background outside the graph. If the transparent check box is set, all pixels using this color will be transparent.

To set the color of the individual curves, select a data point and switch to the **Color** property page. You can now set the color of all curves which may be generated by this data point:

Color Name	Element to which the color applies
Line1	Color for the minimum curve (if enabled).
Line2	Color for the average curve (if enabled).
Line3	Color for the maximum curve (if enabled).
Line4	Color to indicate that the current value of a curve is out of range. If the value axis is adjusted to fit, the real value will be shown, that is, a limited value axis does not affect the actual data which is recorded.

Apart from the colors and the font for the scale, which can be set on the **Common Properties** page, all other properties are set on the **Trend Control** property page. This page is divided in 4 sections, which are described below.

On the top left, the **Value Axis** can be configured. Set the desired *Range* for this axis and enable or disable the *Tick Marks* and/or the *Scale Labels*. On the top right, the **Time Axis** is configured. Select a suitable *Time Span*, which is given in time per page. For example, if you set this to one hour per page, the graph will show the values of the last hour together on one page. To keep older data as well, which is not visible on the first page because it is older than the given time span, set the desired amount of *History Buffer* that should be used by this control. This value is given in pages, that is, if you set the time span to one hour and configure one history page, the control will store the values of the last two hours. Older data will be overwritten by new data.

NOTE: After setting the size, time span and history buffer, check the resulting size of the required data sample buffer at the bottom of the property page. The memory requirements can get significant if you use a larger number of such controls and set a high number of history pages.

In the same section, you may set a minimum *Shift Interval* for the control. The control normally uses the smallest usable shift interval, which is the time it takes for the graph to move by one pixel. The graph cannot be shifted earlier than this, because it needs to move by at least one pixel (can't move by half a pixel). If this interval seems unnecessarily small (each shift will require some processing time), or you want the control to average data over a longer time frame than this, you may set a minimum time here. The control will then use the next higher shift interval which results in an integral shift of the graph (in pixels). The *Flags* to enable or disable the tick marks and the scale are the same as for the value axis.

Below the time axis section, a small information area shows the resulting update rate (shift rate) of the graph, the amount of pixels the graph will be shifted each time, and the amount of memory required for the requested history pages.

On the bottom left, there are some additional **Flags** to be set. Depending on the selected object, there are different flags available.

With the trend control selected, the following options can be set:

- **Enable Cursor:** This option causes the control to become selectable. When selected, a cursor appears which allows navigating through the recorded data (see the next section).
- **Draw Grid:** This option enables a grid which is automatically laid out to fit the current tick mark spacing and allow easier readout of the displayed data. Set the final control size after enabling the grid and choose a size which yields a good looking result for the grid.
- **Preserve Data:** When enabled, the Control is instructed to store the recorded data in non volatile memory, in order to preserve the data across a reboot or power failure. Saving is done in regular intervals, when enough data was collected, or when the unit is shut down in a regular way and thus has a chance to save all unsaved data before shutdown (not possible during a power failure).
- **Auto save data:** The interval given here is the maximum time which may pass before recorded data is saved. This can be used together with slowly moving trends, where only a small amount of data is generated over time and thus the normal save operations, which collect around 4kB of data before saving it, will not be guarded very well against a sudden power failure.

With a data point selected, the following options are available:

- **Draw Minimum:** Enable recording and display of the minimum curve for the selected data point.
- **Draw Average:** Enable recording and display of the average curve for the selected data point.
- **Draw Maximum:** Enable recording and display of the maximum curve for the selected data point.

NOTE: Use the preserve data option with care and avoid unnecessary saving of unimportant data, since these operations may take up a significant amount of system resources and adversely affect performance and life time of the device in case they are heavily over-used in a project.

To save all unsaved trend data manually, use the command *Save All Trend Data* from the command page of the setup menu or build your own save button in the project, which can be implemented by writing the value 5 to the *Command* system register.

NOTE: Even if the preserve data flag is set, a trend control may still discard the stored data when it reboots. This is the case when the controls properties were changed such that the new configuration does not match the stored data anymore, for example because new data points were added to the control or data points were removed, changing the type and amount of data recorded. Recorded trend data is also removed from the device, if there is no control matching the recorded data, which is determined by the UID of the control. That is, if you remove a trend control from the project and reboot the device, the data which belonged to the removed control will be deleted from the system.

Trend Data Access

For every trend control which stores the recorded data in non volatile memory, a file is created on the file system of the device. The file name consists of the object name of the control (as seen on the tree view) and the unique ID of the control (as displayed on the **General** property page. This allows the user to identify the data file belonging to a certain control on the device. The recorded data is available in CSV format, in order to ease processing on the PC.

The files may be downloaded from the device using an FTP connection. User name and password for the FTP account can be set in the project settings (option *Data Access*). The files are located under **`/tmp/trend.`**

Example: A project contains a trend control with **UID 0x122114B1** and has the name "**Trend 1**". The data file for this control will be accessible under **`/tmp/trend/Trend_1_122114B1.csv`** on the device. Spaces in the object name are replaced by underscores to avoid file names containing spaces, which may be a problem for some FTP clients.

NOTE: Assign good names to your trend control objects, to make it easy to identify the data files and relate them to the trends which are visible on the device. Consider to add the name of each trend to the page where the trend is shown, so that the user is able to clearly identify each control and its data file.

If the trend control object name contains non-ASCII characters, the resulting file name will be encoded in ISO-10646 (Unicode) and will be transferred to the client in UTF-8 encoding, according to the FTP protocol extension RFC2640. Clients which support this extension can then display these file names correctly. Most web-browser based FTP clients either detect the UTF-8 encoding automatically or provide an option where the user may set the desired encoding. To maximize compatibility to existing FTP clients, it is desirable to use only ASCII characters for the name of trend control objects.

An easy way to access the files on the device is to use the windows explorer or a web browser and type the following into the address/URL field:

```
ftp::<user>@<address>/
```

Replace <user> with the user name for data access as defined in the project settings and <address> with the IP address or DNS name of the device, for example:

```
ftp::data@192.168.1.20/
```

You will then be asked for the password and the file system contents will be shown. You can now navigate to the required files and download them to the local hard disk of your PC for further processing.

NOTE: Since the trend data files are actually symbolic links to a device driver, you cannot directly open the files on the device. Also, the file size will be shown as 0, because it is not immediately known (the data is generated on the fly, while you are downloading it). You may only download the files. Some FTP client software is known to have problems processing symbolic links to files. They tend to display these files as being directories but any attempt to open this directory will fail, since it really is a file. Examples for such programs are FileZilla and Leech-FTP. If you encounter this problem with your FTP client, use another client or fall back to the windows explorer or the command line FTP client (which is known to work as well).

Operating Trend Controls

Trend controls do not allow data input, but they can be marked selectable. If the control is selectable, touching it on the screen will display a vertical line at the touch point and open a data window, showing the exact data which was recorded for the selected point of time. The control will show the absolute date and time for the recorded data, as well as the value for each of the curves displayed. Each value is printed in the same color as the corresponding curve, to relate the displayed numbers with the curves.

The vertical line may be moved around in the control by dragging it around or touching another location of the curve. The data in the data window will be updated accordingly.

If there is more than one page (the number of history pages was set to 1 or more), the user can flip through the pages by moving the cursor to the rightmost or leftmost end or touching the rightmost or leftmost end of the time axis. Small arrows will appear on both ends of the time axis to indicate a good place to touch if you want to flip pages.

The control will return to normal operation when another control is selected or the user touches any other location outside the selected trend control.

Date Control

The date control is a specialized control to display date, time and calendar weeks. In most cases, the internal system time data point will be connected to the date control. However, it is possible to assign any scalar data type to the date control. In that case, the received value will be interpreted as the number of seconds since the first of January 1970.

There are two different display modes for a date control: a text based mode and a graphical analog clock simulation. Even though one date control can only use one of the two modes at a time, two or more date controls may be used together to display the time as an analog clock and the date as text on the same page.

A font for the text mode can be selected on the **Common Properties** page. All other settings can be done on the **Date/Time Control** property page. There is a *wizard* to generate a suitable format string for text mode, set the *Style* of the control (text or graphic) and modify the look of the *Graphic Style*.

On the **Color** page, the following colors may be set:

Color Name	Element to which the color applies
Text	Text color of the clock in text mode.
Line1	Hour tick marks in graphic style.
Line2	Hour and minute hands.
Line3	Second hand (if enabled).
Selection	Frame drawn around the entire control, if the control is selected.
Frame / Axis	Circle around the clock face (if enabled).

Color Name	Element to which the color applies
Container	Background of the clock face.
Background	Color of the background outside the clock face or behind the text.

Output data points may be connected to a date control, in which case the date control becomes a date input control. The user may then input a date and time using the keypad. The number of seconds which passed since the first of January 1970 and the given date/time will be written to the connected output data points. This value is suitable to write to the system time set register, to update the current system time on the device. However, note that due to limits of the underlying operating system, the system time of the device may not be set to a date before 1/1/1988.

Data Log Control

Data log controls are used to record data based on events, as opposed to trend log controls, which record data continuously over time. The result of a data log is a list of data records which were recorded at specific points in time. Each data record is composed out of one or more visible elements to display the recorded data, like text, number, bitmap or date controls.

The individual data records are created in the folder called *Data Fields* which is part of every data log control. To add a new log record, select *Add Record* from the context menu of the Data Fields folder. Then add the visible elements required to compose your data record to the new folder and attach the data point you want to record. As you lay out the visible elements to build a nice looking data record, the control adjusts its line height to match the area required by your data record.

You will notice that each added data record already comes with a trigger object which has similar properties than a math object. Connect the data points you want to monitor to determine when to store this data record and enter the required formula on the property page of the trigger object. Then select a trigger mode from the available choices.

NOTE: If the trigger mode is set to *any value update*, there is no additional condition to enter in the formula field, since the trigger will fire as soon as any of the connected input data points receives an update.

To limit the frequency at which the trigger may fire and cause data to be recorded, a minimum time between two trigger events can be specified, together with a maximum burst rate, which is the maximum number of events that are allowed in fast succession after a long idle period.

It is possible to add as many data record layouts as needed and define a trigger condition for each of the data records individually. To work on the layout of a specific data record, first select the record in the tree view to make it visible in the LCD preview. You can then continue to work on the record in the LCD view.

Properties specific to the data log control are configured on the **Data Log Control** page. The options currently allow to define if the control should save the recorded data in persistent memory, how often it should save the data and the total number of records to save (when this number is reached, older data is overwritten with newer data). It is also possible to enable or disable the navigation bar at the bottom of the control and set the size of the buttons.

As with trend log controls, the recorded data is available in CSV format for download via FTP. See the section about trend data access for detailed information about the retrieval of this data from the device.

The following colors may be set for data log controls on the **Color** property page:

Color Name	Element to which the color applies
Line1	Highlight color of 3D frames.
Line2	Shadow color of 3D frames.
Line3	Grid lines between data records.
Selection	Frame drawn around the entire control, if the control is selected.
Bar / Bitmap	Button graphics.
Background	Color of the background. If the transparent check box is set, all pixels using this color will be transparent.

Schedule Control

The schedule control is a specialized control to serve as a schedule configuration editor for local and remote scheduler objects. It is possible to connect more than one scheduler data point to the same control. In this case, the title line will allow the user to select the schedule which he wants to view or edit.

For this type of control, it is usually required to load a user defined font. The smallest built-in font is too small to operate the control on the LCD and the medium size built-in font is too wide to be useful for many applications.

Therefore the configuration software automatically searches the list of loaded fonts for a suitable font and, if none was found, automatically loads a font which should be a good choice to get started. A specific font may be selected or loaded any time on the **Common Properties** page.

The properties to set on the **Schedule Control** property page control the basic appearance of the control. The effect of each option can be seen immediately on the LCD preview. If a local scheduler data point is connected to the control, its configuration will be shown in the preview as well.

The following colors may be set for schedule controls on the **Color** property page:

Color Name	Element to which the color applies
Text	Color for all text areas of the control.
Line1	Highlight color of 3D frames.
Line2	Shadow color of 3D frames.
Line3	Grid line color.
Line4	Scroll bar and scroll arrow graphics.
Selection	Frame drawn around the entire control, if the control is selected.
Bar / Bitmap	Background color of the header lines and color for deactivated schedules (day names in the left column).
Container	Background of the day list and time table.
Background	Color of the remaining background (only a one pixel wide frame around the control, where the selection frame will be drawn when the control is selected). If the transparent check box is set, all pixels using this color will be transparent.

Alarm-List Control

The alarm list control is a specialized control to display a list of pending alarms from an alarm server or alarm client data point. It is possible to connect more than one alarm data point to the same control, in which case the control will display a list of all alarms from all connected points in chronological order.

The control always displays the newest alarm at the top with older alarms following further down. At the bottom of the control is a navigation bar which displays the number of pages the list currently uses and allows to navigate through the pages.

Alarm entries which may be acknowledged are shown with a small ACK button at the right end of the alarm entry. Pressing this button will send an alarm acknowledgment back to the reporting alarm server.

The information displayed for each alarm is the date and time the alarm was first reported, the type of alarm, the current state of the alarm and, in the second line, an identification of the alarm source as well as a description and possibly the value which caused the alarm. Depending on the underlying network technology and the fact if the alarm was reported by a local or by a remote alarm server, not all of this information may be available, so that entries may be missing some of the information printed on the second line. The information in the first line is always available and will always be printed.

The following colors may be set for alarm list controls on the **Color** property page:

Color Name	Element to which the color applies
Text	Color for the text printed by the control.
Line1	Highlight color of 3D frames.
Line2	Shadow color of 3D frames.
Line3	Grid line color.
Line4	Button graphics and page information in the navigation bar and text color for the label of the ACK button.
Selection	Frame drawn around the entire control, if the control is selected.
Bar / Bitmap	Background color of the acknowledge button.
Background	Color of the control background. If the transparent check box is set, all pixels using this color will be transparent.

Data Point

Data point objects control the data transfer between a register or a network value and the controls or other data processing objects on the device. To archive this data transfer, there are tree objects involved:

- The **control** element, which acts as the interface to the user, or any other object which processes data, like mathematical objects, alarm generators, or action objects.
- A **data object** as the source or sink of data, for example an internal user register, a system parameter, a network variable or a BACnet server object or client mapping.
- A **data point** object which references a specific data object and thereby links a control to a data source or sink. It also defines the properties of this data link, for example when new data is to be transferred between the data object and the control and how the data should be converted when it is transferred.

The **control** is created as part of the object tree, as outlined in the tutorial. It exists independently of any register or network object. Even if all registers and network objects were to be deleted, the control would not be affected.

The **data object** itself is nor represented as an object in the tree view, because it is not part of the user interface and is not bound to any of the other objects in the tree. Data objects exist on the device independent from the user interface and are identified by a unique ID. They are created and managed in a separate window, the **Data Point Management and Selection** dialog. In some cases they are created automatically, like the data objects representing the system parameters or data objects representing dynamic network variables, which may be present on a CEA709 device.

NOTE: Data objects may be thought of as the source or sink of a data flow, where every object has a defined direction (either source or sink, e.g. data coming in or data going out). For internally created registers, two such data objects are created, one to write data to the register and one to fetch the current register value. Input and output network objects are represented by a single data object with the appropriate direction, BACnet value objects and other objects which may be read and written are represented by two data objects, one for read access and one for write access.

Structured network objects, as available on CEA709 devices, are represented by individual data objects for each of the structure elements, in addition to the object representing the entire network variable. However, most of the complex data objects, which represent more than a single scalar value are not supported by most controls and cannot be attached to them. The following exceptions to this rule apply for the current devices:

- **SNVT_switch:** Data output objects of this type may be directly connected to an alarm generator to control the entire switch.
- **SNVT_alarm2:** As above, data outputs of this type may be connected to an alarm generator to send out alarm messages.
- **SNVT_str_asc:** This and other string data types may be directly connected to a text control. The string received via these objects will be displayed directly on the text control, without a lookup in a mapping table. If the data point is an output point, the string selected from the mapping table is directly assigned to the data point, without converting to a number first. If the string contains non-ASCII characters, they are represented in the ISO-10646 character set and are transferred in UTF-8 encoded format. This way, it is possible to exchange strings in any language between two L-Vis devices using a standard ASCII data type.

The **data point** object is the object created when *Add Data Point…* is selected from the context menu of a control to assign a data point to it. The reason why the assignment of data objects to controls is done via a separate object, instead of directly connecting a physical data object to the control has a number of reasons. The most important ones are:

1. Data objects represent network objects which exist on the device. They must be independent of the existence of any control or other user interface object. If a data object were to be connected to a control and the control is deleted, the data object would be deleted as well. Using a reference object to link the control to an existing data object solves this problem. Deleting the control will also delete the reference object (the data point), but not the data object itself.
2. Many projects need to link multiple controls to the same data object, for example to display a temperature which is received by a certain object from the network on a bar control and on a numeric control at the same time. This would not be possible if the data object would be directly connected to a control, since it could only be at one place in the object tree at a time. A separate link or

reference object is required, which points to the data object from which the control should receive its value updates.

3. Sometimes it is required to apply simple linear transformations to the data objects raw value before it can be displayed. For example, an object may receive a temperature value from the network in degrees Celsius, but the temperature displayed on the device should show degrees Fahrenheit, or a data object provides a speed in meters per second, but the display should read mph or km/h. Such translations can be done by the data point on the fly, while passing values between the control and the data object. This makes it easy to display for example a temperature from an input data object both in degrees Celsius and in degreed Fahrenheit side by side, using two data points referencing the same data object, but using different value translations.

It is important to understand this concept to understand what can be configured on the **Data Point** property page. The key is that there can and usually will be multiple data points referencing the same data object.

Data Point Properties

The following properties can be set on the **Data Point** property page:

Value Translation: If the unit of the data point is known and there are some commonly used translations available for this unit, one of the pre-defined translations can be selected from the drop down list. A custom translation can be defined by filling out the formula below the drop down list. In this formula, NV stands for the value on the network side (Network Value), that is, the value of the data point, and DP stands for the value of the data point as seen by controls or other objects which are connected via this data point.

NOTE: The value translation of a data point can be very useful to modify a value on its way between a data processing object and a register or network value. Using this facility, simple data manipulation like the inversion of a state or the addition or subtraction of a fixed offset can be archived without using a separate math object. For example, an action which toggles a light switch may be implemented by assigning the inverted feedback input (current switch state) to the switch control output. The inversion would be done with `DP=-1*NV+1.`

The *Details* section shows details of the referenced data object, like the name of the underlying network object, the network object type, units, and other information. Also shown is the unique ID of the referenced data object, by which the object may be located in the data point management window for further inspection or modification.

In the *Data Point Update Flags* section, the value update mode is specified. There are three basic modes available, together with some additional options:

- **No Update:** This means that this data point will not request the underlying data object to be updated, even when the value on the control side changes. Useful if this data point represents one element of a structured data object, and updates to this element should not cause the complete object to be transmitted on the network.
- **Focus Loss:** This update mode transmits the new value only when the input control returned focus and left input mode, that is, when the final value is known. Intermediate values, which are for example generated by moving the bar of a bar control around, are not immediately transmitted.

- **Immediate:** All values are immediately transmitted to the underlying data object. This provides direct feedback to the user, while the control is still in input mode and the user is still modifying the value. Currently really only useful for bar controls and controls which use the keypad, since the keypad has + and – keys, which send out intermediate values.
- **System Startup:** The checkbox *System Startup* should be checked to instruct the device to update the value on system startup. If the underlying data object is a value output, the default value or the last stored value will be sent out, if it is a value input, the device will try to request the current value from the sender. Both actions can only be successful if the underlying network technology supports them. In cases where the requested operation cannot be executed, it is silently ignored. For example if the polled flag of an input network variable is not set, the device will not be able to fetch the current value from the sender, since it has no knowledge of the senders network address and therefore can not send a request for a value update.
- **Value Changes Only:** This option causes the data point to forward updates only if the value actually changed. It is very useful to avoid unnecessary operations caused by repeated updates with the same value, provided that the data point does not represent an event, in which case all updates must be processed and this option should not be used.
- **No Invalid Updates:** This option causes the data point to filter out updates which set the value invalid (for example because the value cannot be determined from the network). Normally the invalid state is passed on to the other side. If this option is checked, the update is not forwarded, so that there is no change to the current value.
- **Map Invalid to Default:** This option causes the data point to map invalid updates to the default value specified in the *Default* field. This is useful for input data points which may be unavailable (for example not bound) and this situation is not considered an error. Using this option, unavailable data can be replaced by a safe default. If the invalid state would be forwarded and the value would be used in a calculation, the entire result of the calculation would become invalid, which may not be desired.

In the *Data Point Value* area, the default value for the data point can be set. This will be the value of the data point until a new value is received from either the network or the user or a value which was saved to non volatile memory is loaded after system start. If this field is left blank, the initial value of the data point will be invalid (this state is also visible on the controls).

NOTE: The default value of a data point ultimately refers to the value of the underlying data object. Since the referenced data object can only have one value at a time, the entered default value will apply to all other data points which reference the same data object as well. The entered value will be run through the value translation to determine the resulting value for the underlying data object and this value will be distributed back to all connected data points to maintain consistency. The only exceptions are constant value data points (see below).

If the *Constant Value* checkbox is set, the point is marked as constant and the entered default value will not be overwritten by values received from the network or data entered by the user. In addition, you may set differing default values for data points which reference the same underlying data object, if the data point is marked as constant value.

NOTE: Constant value data points are often very useful together with push buttons of any kind. Create two or more push buttons, for example three text controls with the static texts LOW, MEDIUM and HIGH, enable push button mode and request to always send the current value, then add a temperature output data point to each of the three controls (always referencing the same data object). Now you can set the data points to constant value and enter different values for each of the three points (for example 18, 22 and 24). When the user now presses the LOW button, the value 18 will be sent out. When he presses the MEDIUM button, the value 22 will be sent.

The *Persistent* option is used to request that the current value of the data point should be preserved across a reboot of the device and be used as the new default value, until updates are received. Since the value which will be saved is the value of the referenced data object, this option will also affect all other data points which reference the same data object.

NOTE: The persistent option is useful for output data points which need to be sent out after system boot (*System Startup* flag is set) but are controlled by actions or math objects instead of direct user input. Such data points must preserve their last calculated output value across the reboot, but there is no control which would normally cause the output value to be stored when the user finishes data input. Checking the *persistent* flag will solve this problem.

The *NV Timing* section is used to control the timing of update messages on the network, resulting from this data point. A minimum and maximum send time may be specified for output data points, a receive timeout may be specified for input data points. A value of 0 always means 'unlimited'. The individual parameters work as follows:

- **MinSend:** At least the specified amount of time has to pass between two successive update messages on the network. If the device delivers mode updates than this, intermediate values will not be sent out, until the minimum send time has passed, at which time the current (most recent) value is sent out.
- **MaxSend:** If this amount of time has passed without any updates, usually because the value did not change in the meantime, then the current value will be sent out. This is commonly described as a heartbeat function, used to allow the receiver to detect if the sender is still alive and just not sending new information because there is none, or if the sender has died and therefore no new data is received.
- **PollTime:** Can work as a simple poll interval, or as a receive timeout. Usually used as receive timeout for bound NVs on CEA709 devices and otherwise used as poll cycle time. If used as a receive timeout, it specifies the amount of time after which the device sends out a poll request, if no value update was received. As a poll cycle, it specifies the amount of time after which a periodic poll request should be sent out, independent of any updates which might have been received in the mean time.

Mapping Table

The mapping table is used to map values of numeric data points to text strings, bitmaps and/or colors. The mapping table object controls the display of text controls, bitmap controls, numeric controls and bar controls and may be added to these objects.

A mapping table can include text, bitmaps and colors at the same time. If connected to a text control, the text part will be shown together with the color settings. When the same mapping object is connected to a bitmap control, the bitmap will be shown. Number and bar controls use the color setting only.

Mapping Table Properties

The properties of a mapping table are set on the **Mapping** property page. The *New Entry* button on this page adds a new entry to the mapping table.

NOTE: If you want to add a new entry, but the New Entry button is grayed out, you most likely have a control selected in the tree view which does not yet have a mapping table object attached to it. Go back to the tree view and add a mapping table object, or use the *Load* button to load a mapping table from a file.

The value component of the new entry defines the lower limit for the input value to display the given text, bitmap and/or color. Since multiple entries will be present in the table, the entered values build up ranges, which define the texts and bitmaps to display for every possible numeric value. The valid range for each entry in the mapping table is defined to reach from the value of the entry itself, up to but not including the value of the succeeding entry. If this is the last entry, it is used for all values up to +infinite, since there is no more entry to define an upper bound. For practical reasons, the first entry in the table always ignores the entered limit and is also used for any value lower than its own limit.

Here is an example with four entries:

Value	Text	Displayed when value is…
0	OFF	< 10
10	LOW	10 – 19.9999
20	NORMAL	20 – 49.9999
50	HIGH	>= 50

Once a mapping is defined, it can be stored to a file (*Save* button) and loaded (*Load* button) to define the mapping for other controls in subsequent projects. This way, an archive of frequently used mappings can be built for use in various projects. To use the same mapping for other controls of the same project, just copy and paste the mapping table object in the tree view.

The same mapping table can be used in both directions. Translating incoming values to texts, bitmaps, or colors, as well as looking up a value to send out, when the user selects a given element from the mapping table via a dropdown list or a push button browses the table to find the next entry.

NOTE: All texts, bitmaps and colors used in a mapping table are included in the file when the mapping table is saved, so that the mapping file is self contained and can be loaded and used on different PCs, even when the source bitmap files may not be available.

To define the color for a single entry, either select the entry from the list and click the color button to the right of the text input field, or directly click in the area to the right of the text whose color you want to set (in the color bar). A color selection dialog will appear, from which you may select the desired color.

NOTE: To define a mapping table entry which should not modify the current color, set the color of the entry to *Unset* (shown by the black cross).

To define a color gradient for a number of entries (for example going from red to green), set the color for all entries which should have a specific color and leave all others unset (black cross). Then hit the button to the right of the New Entry

button. This will recognize all entries with set colors as fixed and calculate gradients between them, assigning suitable colors to all previously unset entries.

To set a range of entries back to unset (to re-run the gradient algorithm), you can multi-select the entries from the list and then reset their color back to unset all at the same time.

Action Objects

Action objects are used to execute various actions on special occasions. As such, they are most often assigned to controls, to trigger an action when the user touches, releases, or selects a control. In some cases, they are assigned to data point connectors to watch incoming data point values and trigger an action when a certain value is received.

In any case, the action objects need a parent object which is able to feed the required information to the connected action, such that the action may monitor what's going on and trigger at the right moment. Currently these objects are controls and data point connectors.

For every action object, there are three basic things which need to be defined:

- **Action:** What should be done when the action triggers?
- **Trigger:** When should the action be considered for execution?
- **Condition:** Once triggered, under what conditions should the action be executed and how, if at all, should it be repeated?

When a new action is defined, it is important to think about these three components and make sure the selected choices actually make sense. Each of the above properties may be controlled individually, but not all of the possible combinations will actually make sense. Examples of good and bad configurations and how to avoid the bad ones will be given later on.

Action Properties

Actions are objects which are not visible on the screen of the device, so they do not use any of the common properties like font, position, size, or color. Aside from the **General** properties, which apply to all objects, actions are configured on the **Action** property page.

This page is divided in two sections. The top half is used to define the action that should be executed, when it will trigger, and the conditions under which it will be repeated. The bottom half is used to set options which may be required for some of the actions.

From the first dropdown list, select the action you want to execute. Currently available actions are:

- **Show menu**: Show the current menu, just like performing a press and hold operation on an empty spot on the display. Useful to build menu buttons which show the menu when pressed.
- **Show page**: Jump to the specified page. To select a page, drag a page and drop it on the action object in the tree view. The path to the page will be shown in the option area below.
- **Next page**: Show the next page of a multi-page menu item. This is equivalent to the 'next page' touch gesture and is useful to build a 'next' button.
- **Prev page**: Same as above, but show the previous page.

- **Sound buzzer**: Output a tone on the internal buzzer. The frequency and duration of the tone can be adjusted in the *Options* section. Useful to create audible alarms when a data point or register reaches a certain value.
- **Turn on backlight**: Turn on the LCD backlight, just as if the user touched the display. Useful to turn on the backlight based on information from a presence sensor.
- **Update data points**: Assign a value to all connected output data points. The value to send out can be preset by connecting input data points *to the action object*. Useful to update the value of data points under certain conditions. Often used to save the current value of an input data point to an internal register when a button is pressed, or similar applications. When the connected output data point is a constant value point, the action may be used to write a fixed value to a register or network object when the action triggers.
- **Service Pin Message**: Execute the system command 'send service pin message', which is supported by CEA709 models.
- **Lock Pages (Logout)**: Immediately protects all locked pages. The user has to enter the PIN code again to unlock the locked pages.
- **Back one page**: Show the page from which the current page was reached, similar to the 'back' button in a web browser. The system keeps a record of the last 256 pages visited via the show page action and picks the most recent of them to navigate back one step.

NOTE: The **update data points** action can also be used to increment or decrement the value of a register or of a network output / feedback input pair, which is required to implement up/down buttons to dim light or modify a temperature set point. To do this, connect the register read point (or the network feedback point) as well as the register write point (or network output point) to the action. Use the value translation of the read point to modify the incoming value as required (add or subtract a fixed value). When the action is executed, the modified input value will be assigned back to the output value. Since both refer to the same local register or remote actor, the value of the register or the remote actor will be changed.

Once the action type is selected, choose the desired trigger mode from the dropdown list next to the action list (Execute <action> on <trigger>). The following trigger mechanisms are available:

- **selection**: The action is triggered when the control is selected. A control is selected when the user touches the control and releases the touch screen while still inside the control. If the user moves outside the control after the touch and releases the screen outside, the control will not be selected.
- **value update**: The action is triggered when the *parent object* (the control or data point connector to which the action is assigned) reports a new value, for example because a new value was received via an input data point, which is connected to the *control* (NOT to the action) or when the user enters a new value using the control.
- **state**: This is similar to the value update trigger, but it examines the first data point connected to the parent object to see if it is a multi-state value. If this is the case, the dropdown list next to the action trigger is initialized with the available states and the user can select a state from the dropdown list, instead of entering a numerical value. The action is triggered when the current state equals the state

selected from the dropdown. If the parents value is not a multi-state value, this trigger cannot be used.

- **touch**: The action is triggered when the control is touched. Note the difference to the **selection** trigger, which fires only when the screen is again released inside the control. A touch is also triggered when the control was released by moving outside without releasing the screen, and then returning back inside the control.
- **release**: The action is triggered when the touch screen is released while inside the control, or when the touch position moves outside the control while the screen is still being touched.

NOTE: The trigger of touch and release actions while moving the touch position around between controls (without releasing the touch screen) is consistent with the display of the selection frame. Moving from one control to another without releasing the touch screen will cause the selection frame to follow the movement, always marking the control which is currently touched. The touch and release actions will follow the same pattern, triggering the touch action when the selection frame appears and triggering the release action when the selection frame disappears.

While the action type is independent of the parent object to which the action is connected, the available action triggers vary depending on the capabilities of the parent object, since the action object needs information from its parent to check for trigger and execute conditions. The following limits apply:

- **Control:** If the action is connected to a control, all available triggers and conditions may be used, since a control delivers both a value and user input events (touch, release, select and similar). If a value-dependent trigger mode or condition is used, at least one input data point will usually be connected to the control to deliver new values.
- **Data Point Connector:** If the action is connected to a data point connector, any triggers or conditions which require user input are not available. A data point connector can only feed a current value to the action, therefore the only trigger modes which will actually trigger are **value update** and **state**. From the conditions, the 'while touched' condition cannot be used, since it would require the parent to feed user input information.

NOTE: To avoid confusing situations, it is required that only one object at a time is processing user input. Therefore, if an action is connected to a control and the action uses a trigger mode which depends on user input, for example touch, release, or selection, **the normal input behavior of the control will be disabled, since the user input is forwarded to the connected action**.

The action type and trigger mode are now selected. The next step is to select the condition under which the action may be executed. The following conditions are available from a dropdown list directly below the action type:

- **Execute once:** When the action trigger fires, the action is executed once, without further conditions. This is one of the most widely used settings.
- **Repeat action:** As above, but the action is repeated for a fixed number of times, which is entered in the field to the right of the dropdown box. This is the total number of times the action is executed at most, including the first time. After each execution, a delay which is configured next to the repeat count is inserted. If there is an additional condition (for example a value condition) and

the condition becomes false, any further execution of the action is stopped immediately.

- **Controlled by value:** The action is executed as long as the value of the parent object meets the requirements specified in the *Options* section. Note that if this condition is false at the time the action trigger fires, the action will not be executed. As long as the conditions are met, the action will be repeated, again with a configurable delay between each execution (as above). If the delay is set to 0, the action will be executed exactly once (like the condition execute once) but only of the value condition applies.
- **While touched:** The action is executed as long as the parent object is being touched. As above, observe that this condition must be satisfied at the time the action trigger fires, or the action will not be executed. In practice, this means that the condition 'while touched' is useful only in conjunction with the action trigger 'on touch' or, in rare cases, 'on value update', but not together with 'on selection' because selection of a control implies release of the touch screen.

At this point, the *Execute Action* part of the property page should be filled in completely. The contents of this section should result in a meaningful command when read as a sentence, for example:

Sound buzzer on **touch**. **Repeat action 3** times, waiting **200**ms after each time.

If you read your settings, make sure they make sense and match your goals. For example, you should not end up with a sentence like this:

Next page on **release. While touched**, waiting **100**ms after each time.

The resulting action, even though it is possible to configure it this way, will not do what you want. There are two major problem areas:

- The action is requested to trigger on release of the control, yet, the condition under which the action is to be executed requests the control to be touched. This is a contradiction and will not be satisfied.
- Even if the trigger were to be corrected, using 'on touch', it is very unlikely that you would want this action to show a new page every 100ms while the control is touched. Aside from the delay, which would be too small, there is another major problem here: After the first time the action is executed, a new page will be on the display and the original control will be gone, so you cannot hold on to it.

NOTE: The delay value (waiting xxx ms after each time) **always** applies. The action trigger will always be locked for the given duration after each time the action fired, preventing the same action to fire again until the wait time expired. This can be used to limit the frequency at which an action may fire. If the delay is set to 0, it will be turned off. This also causes any kind of repeated execution to be skipped, so the action is executed only once per trigger event.

Below the *Execute Action* part of the property page is the *Options* section. In this section, any additional information which may be required by action types, action triggers, or conditions, can be set here. Options which are settable are automatically activated, others are grayed out. The following options are available:

- **Value:** Used by the trigger **value update** and the condition **controlled by value**. If both are used together, they use the same settings (differing value settings for the trigger and the execute condition would not make any sense, since the condition must match at the time the trigger fires).

- **Sound buzzer:** Used by the action type ‘sound buzzer’ to set the frequency and the duration of the tone. Useful values for the frequency range from about 500 up to 8000. The most intense sound can be archived at around 4000 Hertz. The duration is normally a value between 100 and 3000ms. (0.1s to 3s). Note that the repeat delay should be larger than the tone duration, since the repeat delay starts to run immediately after the action was triggered, not when it completed.
- **Page:** This is not an input field, but a display of the destination page for a **show page** action. To set a new page, drag and drop the desired destination page on the action in the tree view.

Collections

A collection object works like a folder on a file system. It helps the user to organize objects in groups. Collections can be placed on pages to group objects together and manipulate them as one unit. It is also possible to create nested collections to build complex macro blocks which consist out of a number of smaller building blocks.

At the bottom of the main tree view is a base collection where objects can be collected which work invisibly in the background, without a graphical representation on the screen and without a direct relation to any object on the screen, for example alarm generators, data point connectors, or mathematical objects. However, it is recommended to keep all objects which are required for a specific control or control group to function together on the same page. This way, the page continues to work when it is copied or moved to another project, because the required invisible objects are copied together with the page. The base collection outside of the main menu should only hold objects which are related to the device, rather than specific page functionality.

Collection Properties

Aside from the properties on the **General** property page, which apply to all objects, a collection keeps record of the position and size of the bounding box which can be drawn around all visible objects contained in the collection. This data can be seen on the **Common Properties** page.

Collection Handling

If a collection is part of a project page and contains visible objects, a bounding box around all objects contained in the collection is drawn in the preview when the collection is selected. Using this box, the entire collection may be moved to another location on the page. It is also possible to resize the bounding box, which will evenly spread out the contained objects. For example, if a collection contains three objects in a horizontal row where the second object is located in the center, resizing the bounding box will keep the leftmost object at the left edge, the rightmost object at the right edge and the middle object in the center of the bounding box, that is, the relative position of each object in the collection does not change.

NOTE: A collection can only be resized when there are at least two visible items inside the collection. In addition, resizing is only possible in a direction where at least two controls are not at the same position. This is a direct consequence of the way resizing works.

To select a control inside a collection, the easiest way is to select it from the tree view at the left. If the control is to be selected directly in the preview, there are at

least two objects on top of each other (the collection and the control). If there are nested collections, or if controls overlap on the page, there may be even more layers of objects. There are different ways to select a specific object in such a case: Each of these methods will:

- **Left mouse button double click** moves the current selection down to the next object under the cursor in the layer stack. When the bottom most control is reached, the selection moves back to the topmost control.
- **Middle mouse button single click** does the same as the left double-click.
- **Tab key** moves the selection down to the next object on the current page in the tree view. From the last object on the page, the selection moves back to the first object on the same page.

Using the tab key is especially useful while using the keyboard cursor keys to move and resize a control. Using the tab key to switch the selection to the next object on the page can be convenient in this situation.

Alarm Generators

The alarm generator object is used to monitor input data points and issue alarms based on rules which are set on the **Alarm Generator** property page. To add a new alarm generator, use the context menu of a collection object in the object tree and select 'Add Alarm Generator'. A new alarm generator object will be created and connected to the collection object.

Once the alarm generator object is created, connect the input data points which should be monitored. Each of the connected input data points will show up on the alarm generators property page, where the monitoring rules can be defined.

NOTE: It is sometimes useful to connect the same input data point twice or more times to the same alarm generator, when the desired alarm conditions are too complex to cover in one rule, for example different rules for alarm set and alarm clear or multiple non-overlapping value ranges which should trigger an alarm. In this case, assign different names to the connected data points on the **General** property page, so that you may distinguish between them later.

Once the required input data points are connected, the alarm generator needs one output data point to which the result should be written. The desired output data point must be connected before the alarm generator can be configured, because the type of data point determines the configuration options. The following data point types may be used as outputs for the alarm generator:

- **Alarm Server:** On CEA709 devices, a local alarm server data point may be connected to deliver the alarm to remote alarm clients and display the alarm on an alarm list control. The alarm server keeps record of all pending alarms, delivers them to any connected clients and manages acknowledgement of alarms.
- **Scalar Value:** Any data point representing a single scalar value, for example a register. In this case, the alarm generator uses the connected data point as a Boolean value, setting it to either 0 (OFF) or 1 (ON). Using the data points scaling factors, this input may be translated into any two values, one to signal 'alarm clear' and one for 'alarm set'. This is most useful if the generated alarm is to be processed further or displayed on the L-Vis device, for example to trigger actions or display warning messages.

- **Multi-State Value:** Similar to a scalar value, but the alarm generator can be configured to set the output to any of the available states, which can be selected easily from a dropdown box. Useful on BACnet devices, where a multi-state point may be used to signal a number of different alarm conditions.
- **SNVT_switch:** Available on CEA709 devices, a data point representing an entire switch variable may be connected. In this case, the alarm generator sets both value and state of the connected switch to either ON/100 or OFF/0. Useful in cases where the generated alarm is to be processed by a remote device which uses one switch input for each alarm.
- **SNVT_alarm2:** Available on CEA709 models, a data point representing a SNVT_alarm2 structured NV may be connected. In this case, the user may set all elements of the alarm2 structure to the desired values, including the alarm priority and a description. This is most useful to communicate the result to a remote device which provides a compatible alarm input variable.

Alarm Generator Properties

Once all inputs and the output are connected, the alarm generator may be configured on the **Alarm Generator** property page. For each of the connected inputs, an independent set of parameters is required. The available input points are listed in the top left area of the property page.

NOTE: If logic or arithmetic operations are required to determine an alarm condition (for example signal an alarm when T1 > T2), a mathematic object is required to conduct the required operations. The result, which is conveniently stored into an internal register, is then monitored using the alarm generator.

The suggested workflow to configure the alarm generator is as follows:

- First, select the input point for which the monitoring rules should be configured.
- Define the *Alarm Condition* using the radio buttons at the bottom left of the page. The available choices allow basic monitoring functionality and always define the condition, under which the alarm should be SET. If the value no longer satisfies the condition, the alarm will be cleared. To filter out spikes, it is usually good to set an amount of time which the alarm condition needs to be satisfied, before the alarm is actually set. The default of one second is often a reasonable value.
- Define the *Data Point Value Range*. Depending on your choice for the condition, you may need to enter values either for both (minimum value and maximum value) or only for one of the two. If your condition is inside or outside range, you need to enter both values to define the range, for the condition ‘above max’ only the maximum value is required and for the condition ‘below min’ only the minimum value needs to be filled in.
- Define the *Action* that should be taken. The basic choice here is to have the alarm generator SET the alarm when the condition is satisfied and also CLEAR the alarm when the condition is no longer satisfied. However, you may want to only SET the alarm when the condition is met and not clear it again, because you may require the user to manually clear the alarm later. In this case, use the ‘set on alarm enter’ action, which will only set the alarm, but will never clear it. To actually clear the alarm, you can either use

other means to update the alarm output variable, or you can have a separate input on your alarm generator and define a rule for this input, which will eventually clear the alarm, using the 'clear on alarm leave' action.

- As the last step, define the desired output, either for both conditions (set and clear) or for only one of them. The required input fields will be active, while the other ones will be grayed out. Note that the description field may currently only contain ASCII characters.

The above procedure needs to be repeated for all connected input data points.

Application Hints

While it is pretty straight forward to configure a simple alarm generator to output an alarm when for example a temperature reaches a certain maximum value, the alarm generator can be used for more complex applications as well. Two of the most often used applications are described in more detail in the next sections.

Alarm Condition with Hysteresis

Consider you want to issue an alarm when a temperature rises above T1, but the alarm should not be cleared unless the temperature falls below T2, which would be less than T1. Similar to a thermal protection which, once it activates, turns off the device and does not turn it back on until the device significantly cooled down, to avoid constant ON/OFF cycles.

Such an application can be done by connecting the temperature data point two times. To distinguish between them, append SET to the name of the first data point and CLEAR to the name of the second data point (on the **General** property page).

On the **Alarm Generator** property page, configure the SET data point to cause the *Action* 'set on alarm enter', enter T1 as the maximum value of the *Data Point Value Range,* and select *Above Max* for the alarm condition. For the *Alarm Output*, choose the desired output value for the *Set Action*. The *Clear Action* should be grayed out, since the rule specifies no alarm clear action.

Now there are two options available to configure the CLEAR data point. Here is the first one:

As for the SET data point, keep the *Alarm Condition* at *Above Max,* but enter T2 as the maximum, instead of T1. For the *Action,* select *Clear on Alarm Leave* and select the desired output value from the dropdown list at the right. This time, the *Value for Alarm Clear* box will be active, while the others will be grayed out.

This method is the correct way of doing it, but it may be counter-intuitive. Many people choose *Below Min.* for the alarm condition, because they want something to happen when the temperature falls below T2. However, the condition specified here is always the *Alarm Condition*. It defines the conditions under which the alarm is considered to be SET. It does not define *when* something will happen. This is done using the *Action* setting. The alarm condition in this example is still 'above a certain temperature' and action will be taken when this alarm condition is CLEARED, e.g. the device has cooled down enough. Now, if this seems unreasonable, here is an alternative approach:

You may configure the CLEAR data point using the alarm condition *Below Min.* and enter T2 as the minimum value of the *Data Point Value Range*. Since you now defined 'below T2' as the alarm condition, you need to take action when the alarm is SET, so the action must be *Set on Alarm Enter*. Now select the desired output value from the *Value for Alarm Set Action* dropdown list. This value will represent the cleared alarm, since the temperature now is below T2. Overall, this way seems more awkward than the first, because the alarm output is cleared by causing an alarm condition.

Alarm Clear via Data Point

Similar to the first example, but instead of defining a temperature T2 below which the alarm will clear automatically, a manual input should be used to clear the alarm. Of course, the two examples may be combined to have both, automatic clearance below a safe temperature T2 plus manual clearance as long as the temperature is at least below T1.

First, we need to connect the input data point, via which the alarm should be clearable. This may be the state component of a switch, a Boolean value, a register, or any other scalar value. We will assume an internal register for this example, which we assume will be set by the user pressing a button on the display. We assume that pressing the button will set the register from 0 to 1 and releasing the button will set it back to 0 again.

The first part is the same as in the previous example. The temperature variable is connected to the alarm generator and configured to cause an alarm when the temperature rises above T1.

To clear this alarm, we configure the connected register data point as follows:

Set the *Alarm Condition* to *Above Max.* and enter a time delay of for example 3s. This will require the user to press and hold the button for 3 seconds, before the alarm will be cleared. Enter a value between 0 and 1 for the maximum of the data point value range, for example 0.5 would be a good value. For the *Action*, select *Set on Alarm Enter* and select the desired output value for a cleared alarm from the dropdown list named *Value for Alarm Set Action.* This is because we actually define an alarm condition when the button is pressed. As a result of this alarm condition, we then reset the 'real' alarm.

NOTE: The above examples may of course be combined, to have automatic alarm clear when the temperature falls below T2 and manual clear via a button when the temperature is at least below T1.

Data Point Connectors

Data Point Connector objects are used to receive a value from one or more input data points and copy the received value to all connected output data points or other objects which accept a value, for example action objects.

A data point connector has no visible representation on the display and is therefore not related to any of the visible objects. It can only be connected to a collection object, as described earlier. To create a new data point connector, use the context menu of the collection object to which you want to add the data point connector. Other than the general properties like object name and description, there are no further properties to set.

Whenever a new value is received via one of the connected input data points, the value will immediately be forwarded to all connected output data points. This can be useful for example to connect an internal register to a network output. If the register contains the result of a complex calculation or is controlled by various objects across the whole project, it is easier to have one single point of connection to the outside world, instead of connecting the network output in parallel to the register write data point at every location where the register is written.

It may also be used to connect input and output data points which are of similar but incompatible types, for example receive a value from a SNVT_temp variable and output its value via a SNVT_temp_f variable. If a structured data point should be connected entirely to another data point of the same type, each of the structure elements needs to be connected individually using a separate connector, because each connector is only able to handle single values.

NOTE: The functionality of a data point connector or any other object for which a change of an input value causes updates to an output value without any further conditions or limits is inherently dangerous. You must be careful not to cause endless update loops using these types of objects. See the section about update loops for a discussion of the problem.

Mathematic Objects

Mathematic objects are used to do calculations on connected input data points and assign the result to the connected output data points. The object calculates its formula every time an update is received via one of the connected input data points, so that the output value is always accurate. If a complex formula is used, which operates on a large number of input data points, the resulting update rate of each input data point should be considered, so that the resulting total update rate remains reasonable.

Math Object Properties

Mathematical objects are configured on the **Math Object** property page, where basically the formula is entered. Before doing so, it is important to connect the required input data points to the object, so that they are available as variables for use in the formula.

All connected input data points are listed on the left side of the property page and variable names are assigned to the data points in the order in which they are connected to the math object. Variable names start with v1 and continue with increasing numbers, like v2, v3, v4 and so on. There is a limit of 127 input data points per math object. Formulas using more than 127 input variables must be split into individual sub-expressions, which should be done anyways since a formula with such a large number of variables becomes unreadable.

NOTE: Always keep in mind that the order in which the input data points are connected to the math object in the tree view defines the assignment of variable names for the formula. If you replace input data points when the formula was already specified, be careful not to mess up the data point order and thus the result of your calculations.

Using the assigned variable names, the user may now enter a formula directly below the list. As you enter the formula, it will be parsed and the resulting sequence of calculations will be displayed in a list at the right of the property page. This list shows your formula in reverse polish notation (RPN), also known as postfix notation, as used by many scientific pocket calculators. Users of such calculators will be immediately familiar with this list and may find it more convenient to construct the formula using the list at the right, instead of the input at the bottom. To learn more about postfix notation, there are a lot of resources and articles readily available on the internet.

NOTE: When the formula entered at the bottom is still incomplete and does not yield a meaningful command sequence, the list showing the RPN equivalent will be empty. This allows the user to immediately see if the current input is valid or not.

The operators +, -, /, *, %, AND, OR, XOR, ^, &, |, =, !=, <, >, <=, >= can be used instead of the explicit function calls. Further, it is possible to use parenthesis to define the precedence of the operations.

The buttons and input fields in the middle of the page are used to directly edit the formula using the reverse polish notation. To add a variable to the stack,

either double click the variable in the list at the left or select it and click the *Add Variable* button. To add a constant value to the stack, enter the value in the input field above the button *Add Value* and then press the button. To add a function to the stack, select the desired function from the dropdown list and press the *Add Function* button. When a function is added to the stack, it will first fetch as many values from the current stack as it needs input values, then execute its operation, and put the result back on the stack.

NOTE: Even if you use the infix notation at the bottom to enter your formula, the dropdown list of available functions will be useful, to look up the names of functions you want to use and see how many arguments they accept.

Application Hints

A few functions end with a … (three dots) in the argument list. This means that they accept a variable number of arguments. When used in the formula, they will fetch all available values from the stack (in RPN syntax) and then calculate the result, which will be put back on the stack and be the only value on the stack, since all other values were used as input to the function.

This behavior causes some limits in how these functions may be used. You are on the safe side, if you use such a function only as the outermost function, or, in RPN, as the last function on the stack, for example:

sum(v1, v2, exp(v3, -1))

If you have to use it as an argument to another function, it may only be the first argument, otherwise the formula cannot be processed by the math object, which internally uses an RPN machine, with precompiled instructions for optimal performance. Example:

add(avg(v1, v2, v3), 5) or the equivalent avg(v1, v2, v3) + 5 will work.

add(5, avg(v1, v2, v3)) or the equivalent 5 + avg(v1, v2, v3) will NOT work.

To limit the number of re-calculations, the data point update option *Value changes only* should normally be checked on all connected input data points. This avoids recalculating the formula and writing a value to the output data point when it is already clear that the result will be the same, because the input value did not change. The same option can also be checked for the output data point to avoid unnecessary writes to the output data point, in case the inputs changed but the result of the formula is still the same.

NOTE: Especially for projects which use a lot of cascaded formulas, where the result of one formula is used as input to a number of other formulas, it may cause a big difference in CPU usage whether results of the same value are forwarded to other math objects in the system or not, because they will trigger recalculation of a potentially large number of other formulas, which will generate even more results of the same value (since the originating value did not change).

Function List

The following function calls are currently supported:

Function	Return Value
`add(v1,v2)`	`v1 + v2`
`sub(v1,v2)`	`v1 - v2`
`mul(v1,v2)`	`v1 * v2`

Function	Return Value	
`div(v,d)`	`v / d`	
`mod(v,m)`	Returns the remainder of dividing v by m, where v and m should be integer values. Fractional values will be rounded to the nearest integer automatically	
`max(v1,...)`	Returns the maximum of all values on the value stack	
`min(v1,...)`	Returns the minimum of all values on the value stack	
`avg(v1,...)`	Returns the arithmetic mean value of all values on the stack	
`log(v)`	Returns the natural logarithm of v	
`log2(v)`	Returns the base 2 logarithm of v	
`log10(v)`	Returns the base 10 logarithm of v	
`exp(v)`	Returns the value of e (the base of natural logarithms) raised to the power of v	
`exp2(v)`	Returns the value of 2 raised to the power of v	
`exp10(v)`	Returns the value of 10 raised to the power of v	
`sqrt(v)`	Returns the non-negative square root of v	
`pow(v,exp)`	Returns the value of v raised to the power of exp	
`round(v)`	Round v to the nearest integer	
`floor(v)`	Round v down to the nearest integer	
`ceil(v)`	Round v up to the nearest integer	
`sum(v1,...)`	Returns the sum of all values on the stack	
`and(b1,b2)`	logical AND of the Boolean values b1 and b2	(`b1&&b2`)
`or(b1,b2)`	logical OR of the Boolean values b1 and b2	(`b1||b2`)
`xor(b1,b2)`	logical exclusive OR of the values b1 and b2	(`b1^b2`)
`not(b)`	logical inverse of the Boolean value b	(`!b`)
`lt(v1,v2)`	returns 1 if v1 is lower than v2, else returns 0	(v1 < v2)
`le(v1,v2)`	returns 1 if v1 is lower or equal v2, else 0	(v1 <= v2)
`eq(v1,v2)`	returns 1 if v1 equals v2, else 0	(v1 = v2)
`ge(v1,v2)`	returns 1 if v1 is greater or equal v2, else 0	(v1 >= v2)
`gt(v1,v2)`	returns 1 if v1 is greater than v2, else 0	(v1 > v2)
`if(b,vt,vf)`	returns vt if b is true, else returns vf	(b ? vt : vf)
`encode(b1,...)`	Reads all values from the stack, converts them to Boolean values and encodes them into an integer value, where the first value is used as the LSB and the last value as the MSB.	
`sin(v1)`	Returns the sine of v1, where v1 is given in radians	
`cos(v1)`	Returns the cosine of v1, where v1 is given in radians	
`tan(v1)`	Returns the tangent of v1, where v1 is given in radians	
`sinh(v1)`	Returns the hyperbolic sine of v1, which is defined mathematically as (exp(v1) - exp(-v1)) / 2	
`cosh(v1)`	Returns the hyperbolic cosine of v1, which is defined mathematically as (exp(v1) + exp(-v1)) / 2	
`tanh(v1)`	Returns the hyperbolic tangent of v1, which is defined mathematically as sinh(v1) / cosh(v1)	
`asin(v1)`	Returns the arc sine of v1; that is the value whose sine is v1	
`acos(v1)`	Returns the arc cosine of v1; that is the value (in radians) whose cosine is v1	
`atan(v1)`	Returns the arc tangent of v1; that is the value (in radians) whose tangent is v1	
`asinh(v1)`	Returns the inverse hyperbolic sine of v1; that is the value whose hyperbolic sine is v1	
`acosh(v1)`	Returns the inverse hyperbolic cosine of v1; that is the value	

Function	Return Value
	whose hyperbolic cosine is v1
`atanh(v1)`	Returns the inverse hyperbolic tangent of v1; that is the value whose hyperbolic tangent is v1
`gamma(v1)`	Returns the value of the Gamma function for the argument v1. The Gamma function is defined by Gamma(x) = integral from 0 to infinity of t^(x-1) e^-t dt. It is defined for every real number except for no positive integers. For nonnegative integral m one has Gamma(m+1) = m! and, more generally, for all x: Gamma(x+1) = x * Gamma(x) For x < 0.5 one can use Gamma(x) * Gamma(1-x) = PI/sin(PI*x)
`abs(v1)`	computes the absolute value of the argument v1

Data Point Management

Concept

As outlined in the description of the Data Point object, the network variables, BACnet server objects, client mappings, user defined registers, and system parameters are represented by objects which exist on the device independent of any controls or other objects in the object tree. These data objects are only referenced from the data point objects in the tree by their unique ID.

While some of these objects are created automatically, most of the data objects need to be created by the user. There are ways to manually create individual data objects, import object definitions from CSV files or scan the network and create new data objects based on the information collected by the network scan. Once created, a data object may be used to exchange data with other devices on the network, store and load internal registers, or access internal system parameters.

Every data object on L-Vis has a distinct direction of data flow, either read (input) or write (output). This is important because the data flow direction determines how a data point will be used by other objects in the tree. For example, a mathematic object will assign variable names (v1, v2…) to all input data points and write the result of the calculation to all output data points. For controls, the direction of the attached data points determine if the control will be selectable (to input new data) or not.

NOTE: The direction is defined from the point of view of the L-Vis device in question, referring to the network side, not the application side. Therefore, an input data object will receive new data from the network and deliver this data to the application running on the L-Vis device, whereas an output data object will transmit new data from the L-Vis out to other devices.

All data objects fall into one of the following categories:

- **System Parameter:** This is a data object which cannot be created by the user. It is provided by the device to modify certain internal system parameters, like the time zone, IP address, BACnet instance number, or others, or read the current value of a system parameter like the current time, CPU load, free memory, and so on. A system parameter object is either a read-only or a write-only value, depending on the direction of the data object.
- **Register:** A register is a place to store data internally, instead of communicating with other devices on a network. Registers are used to internally transfer data between objects, for example when a mathematic object calculates a value which should be displayed on a control, the result of the calculation is stored to a register and the control reads the value from the register for display. A register is therefore always represented by two data objects. One to write a new value to the register and one by which the current value of the register can be read.
- **Local Network Object:** A local network object refers for example to a static or dynamic network variable (CEA709 models) or a BACnet server object (BACnet models) which exists on the device. Most of such objects are either write-only (output NV, BACnet input objects) or read-only (input NV, BACnet output objects). They are therefore represented by one data object with the appropriate direction. One exception to this rule are BACnet value objects, which may be read and written and which are therefore represented by two data objects, just like registers.
- **Remote Network Object:** A remote network object is a reference to some object existing on a remote device on the network. Such a reference is called a *client mapping* on BACnet devices, since it maps the value of the existing data object on the L-Vis device to a data point on a different device. Depending on the direction of data flow, the mapping can be either read (poll or COV) or write. There may be more client mappings for the same remote object, for example to a remote BACnet value object, which can be read and written and is therefore represented by two client mappings. On CEA709 devices, external network objects are called *external NVs* since they are references to NVs located on other devices. There is currently only one reference per external NV. A remote network object is usually only constructed from data retrieved by a network scan and will only work as long as the referenced object does not change its configuration.

NOTE: From the data which is retrieved by a network scan, it is possible to create a local network object from the client mapping. The user will decide if a client mapping or a local network object is the better solution, which depends on the network technology and the type of installation. For CEA709, it is usually better to create local network objects and use a network management tool to define the bindings to other devices in the network, for BACnet it may be more convenient to use client mappings instead.

User Interface

Since the data objects are not part of the object tree shown in the main window, there is a separate window to manage these objects. The same window is also used to select one or more data objects, when a data point is to be added to the object tree. It is therefore possible to create and select a data object in one go.

The window is divided into three sections:

Folder List

At the left is a list of folders which is used to sort the available data objects by their category. There are a number of predefined folders available:

- **Import:** This folder has two sub-folders. One is used to hold data retrieved from a network scan, the other one is used to display data imported from files. Data objects in the import folder are not stored on the L-Vis device when the project is downloaded. They represent data objects which are available on remote devices and are shown here as templates to create suitable data objects for use on the L-Vis device (see the section Remote Network Object for details).
- **Local NVs / Server Objects:** Objects which represent a local network variable or local server object are located in this folder. Select the folder and use the *New* button or the context menu to create a new local data object.
- **External NVs / Client Mappings:** Objects which reference remote network variables or server objects on other devices, without connection to a local network object, are located in this folder. These are usually data objects which were created from points in the import folder, by using the option *Use on Device* from the context menu of the imported point.
- **Register:** This is a folder for internal registers created by the user. To add a new register, select this folder and then use the *New* button or the context menu to add a new register object. As explained before, a new register will automatically yield two new data objects (read and write).
- **System:** This is the folder in which the available system data objects are located. All these objects are automatically created and cannot be removed or modified in any way. They can only be selected to create a new data point for the object tree.
- **Calendar:** This folder is used to hold a locally available calendar object with its calendar patterns (definitions of day classes like holiday, maintenance day, and so on). Current devices allow one local calendar object. To create it, select the folder and use the *New* button or the context menu.
- **Scheduler:** This folder is used for local scheduler objects. Each of these objects will connect to a local scheduler on the device and will be configurable through this data object, that is, the data objects transfers *scheduler configuration data* between the actual scheduler present on the device and the user interface.
- **Alarm:** This folder is used for local alarm servers. On CEA709 devices, only one alarm server may be created, which basically represents the node object of the device which is used to manage system alarms. On BACnet devices, an arbitrary number of alarm server objects may be created, where each alarm server object will be connected to a separate notification class object on the device.
- **Remote Devices:** This folder is used to collect all remote calendars, schedulers and alarm client objects which were created from network scan data. For each remote device, a subfolder will be created where the objects referencing this device are collected. Note that references to normal external data points go into the External NV or Client Mappings folder.

Using the context menu on a folder, sub-folders may be created to organize the available objects. If new objects are created automatically, they are usually

placed in the base folder and can then be moved by the user to any of his sub-folders.

Data Object List

At the top right, a list of all data objects which are available in the selected folder is shown. From this list, objects may be selected (including multi-select) in order to modify some of their properties. A double-click will select the data object and then close the window (same as the OK button), which is useful when adding new data point objects to the object tree in the main window.

The columns of the list will vary depending on the type of objects shown. Always visible are the data object name and the unique ID by which this object may be referenced. Also shown is the number of times this object is currently referenced from the main object tree (the L-Vis project). Only data objects which are currently unused (the Use column shows 0) may be removed from the list.

New objects may be created in the selected folder by pressing the *New* button to the right of the list or via the *New* command in the context menu. The list may be sorted by a click on the desired list column.

When an entry is selected, detailed property information is shown below the list, in the property view.

Property View

The property view is the area below the data object list and is used to display detailed information about a selected data object. Some of the properties may be modified in this area, others (marked with a lock symbol) are read-only.

Object Creation

New objects can either be created manually, or from template objects which were automatically created based on information provided by a file or a network scan. The various objects and the way to create them are explained in the following sections.

User Register

A new user register is very easy to create. Select the folder named Register and click the *New* button. A new dialog appears, asking for two names, a *Datapoint Name* and a *Register Name*. The first one is used as a base name for the data objects which will be created. The suffix _Read or _Write will be appended to this name, to identify the read and the write point. The second is the name of the register itself. You may leave either one or even both names empty, in which case a suitable default will be chosen.

Local Network Variable (CEA709)

For CEA709 models, local network objects refer to local network variables on the L-Vis device. If there are dynamic NVs present on the device, suitable data objects will be created automatically. All manually created objects will therefore create additional static network variables on the device.

NOTE: Adding, removing, or otherwise changing the static network variables of a CEA709 device may have an impact on the integration of the device in your network. The configuration software will automatically determine if your changes need special attention and warn you if the required modifications can

not be made automatically. Refer to the chapter Connecting to the Device for more information about this topic.

To create a new static NV, select the folder named *Local NVs* and use the *New* button or the context menu to add a new data object. A new dialog will open and request the required information to create the new NV, which is:

- **Datapoint Name:** Enter a name for the data object. If this is left blank, the data objects name will be derived from the programmatic name of the network variable.
- **Programmatic Name:** The programmatic name of the network variable on the device. There are certain restrictions to this name, which originate from the underlying network technology. For example, the name may not exceed 15 characters. Also, the name should start with the prefix nvi or nvo. If this is not the case, a suitable prefix will be added to the name automatically (depending on the selected direction).
- **Resource File:** This dropdown list contains all resource files currently installed on the system. Select the desired resource file, which contains the data type you want to create. The standard network variable types (SNVT_xxx) are defined in the resource file called STANDARD.
- **Type:** The desired type of the network variable. The available types in this dropdown depend on the resource file selected before.
- **Direction:** Input or output, as seen from the network side.
- **Functional Block:** The functional block in which the NV should be located. L-Vis provides an array of eight functional blocks to organize your NVs and keep them separate from other NVs on the device which are managed by the device firmware.
- **NV Flags:** Flags for the newly created NV. You may leave these untouched. Most of the flags will be handled by the network management tool later on. The most important one which cannot be set by other tools is the polled flag. This is automatically set for newly created NVs as required.

Local Server-Object (BACnet)

On BACnet models, local server objects may be created to communicate with other devices on the network. The basic object types supported are analog, binary and multi-state, each available as input, output or value object. Since a value object may be read and written, much like a register, two data objects will be created for each value server object.

NOTE: BACnet defines the direction of data flow from the point of view of the application running on the L-Vis device. An analog input object therefore accepts input from the user and transmits this data out to other devices on the network. An analog output object receives data from the network and outputs it to the application (show data on the display). A BACnet input object is therefore represented by an output data object, whereas a BACnet output object is represented by a data input object.

To create a new server object and the required data object(s) to represent it, select the folder named Server Objects and use the *New* button or the context menu to add a new object. A dialog will open, requesting the required information to create the new server object. The following data may be entered:

- **Datapoint Name:** This is the name of the data object representing the BACnet server object. You may leave this empty, in which case the server object name will be used.
- **Object Name:** The name of the server object to be created. This is the name which will be seen by other devices on the network.
- **Object Type:** Select the required object type here. Keep in mind that 'input' and 'output' here are according to BACnet naming rules for objects, as explained above.
- **Engineering Units:** Optionally, specify the engineering units for your server object. This will be available to other devices on the network as a property of your server object.
- **Description:** As above, optionally specify a description which will be available as a property of your server object for other devices or system integrators to read.
- **Device Type:** Optional property for your object, as above.

Once all the required information has been filled in, the button *Create Server Object* is used to create the new server object and the required data object(s) to represent it. As explained before, you will get two data objects if you create a server object of type 'value', in order to be able to read and write your object.

Remote Network Object

Since there is a lot of information required to create a mapping for a remote network object, such objects are usually only created from existing templates. The first step therefore is to either scan the network for remote network objects or import a file, to get a list of available template objects from which new client mappings may be created.

CSV / EDE Import

Use the context menu of the file import folder and select the command *Import File*. Browse to the CSV file you want to import and select it. For BACnet models, standard EDE files may be imported through this method. For CEA709 models, a similar file format was specified so that tools may be developed which are able to output data in a format the configuration software is able to read. An example CSV file for CEA709 is installed together with the configuration software.

Once opened, the contents of the file will be parsed and suitable data object templates will be created in the file import folder. These templates are then used in a later step to create client mappings for use on the L-Vis device (see the section Create Mapping below).

Network Scan

Scanning an existing network is another way to generate template points. Depending on the type of device and the current operating mode of the configuration software, there are different ways to scan the network:

- **BACnet, no connection to a device:** In this mode, there is currently no way to scan the BACnet network. To execute the scan, a connection to a BACnet device must be established first.
- **BACnet, connected to a device via FTP:** The network can be scanned by the L-Vis device, which reports the results back to the configuration software. To start the scan, use the context menu of the scan folder and select *Scan BACnet Network*.

- **CEA709, no connection to a device:** In this mode, network scanning is currently not possible. Connect to a device first.
- **CEA709, direct connection (not LNS mode):** In this mode, network scan is currently not possible, because the scanner engine on the device can only be operated over a TCP/IP link.
- **CEA709, connected to a device via FTP:** In this mode, the device is able to execute a network scan and report the results back to the configuration software, similar to the BACnet scan. Since the device scans the physical network, the results can only include information which is stored on the devices in the field, not information which may be present in an LNS database, like a device name, functional block names, or NV display names. To start the scan, use the context menu of the scan folder and select *Scan CEA-709/852 Network*.
- **CEA709, connected to a device in PlugIn mode:** In this mode, scanning is done on the LNS database. The devices do not need to be physically present. The information gathered from this type of scan will usually include more information, because there is more information about the devices available in the LNS database. However, finding a device through this type of scan does not necessarily mean that the device will actually be available on the physical network, whereas the results from a direct network scan will reflect the network as currently seen by the L-Vis device running the scan. To start the scan, use the context menu of the scan folder and select *Scan LNS Database*.

A new window will open, which is used to conduct the network scan. Depending on the type of scan, the window will contain different controls and options to conduct the operation. A few things to note are:

- **BACnet Scan:** As the first step, the current list of devices should be updated using the button *Refresh Device List*. After a while, the list of available devices on the network will be shown in the device list. Now one or more devices may be selected from this list and the objects available on the selected devices can be scanned by pressing the button *Scan Objects*. This step may be repeated for all required devices. For each device, a new sub-folder will be created and the objects found on the device will be created in this sub-folder.
- **CEA709 Scan:** Note that the device you are connected to must be commissioned in order to execute the scan. If it does not yet have a valid network address, a suitable address may be assigned in the area called *Connected Scanner Device*. If you want to see a list of all reachable devices, use the button *Discover Devices*, alternatively start scanning for service pin messages by pressing the button *Discover on Service Pin*, then go through all required devices and press the service button, which will add the device to the list of available devices, and stop the process using the *Done* button when finished. Once the list of devices is ready, use the button *Scan Device* to get a list of objects available on the device.
- **LNS Database Scan:** The current network will be selected from the database automatically. Select the desired channel from the list of channels at the right to see a list of devices on that channel. Now either scan all devices on the channel using the button *Scan Channel*, or select individual devices from the list and use *Scan Device* for individual device scan.

When you are done with all the required devices, close the scanner window and return to the data object management window. The scan folder should now have

a sub-folder for each of the scanned devices, containing objects representing the data points available on these devices. Now the required mappings may be created from these points (see next section).

Create Mapping

Browse through the available points in the import folder and select the data points for which mappings should be created. Multi selection within the same folder is possible. Then open the context menu and select *Use on Device.* For all selected points, a suitable remote data object will be created.

NOTE: The data direction of the points created in the import folder are set from the point of view of the scanned device, since they represent data objects which are available on the remote device (for a network variable input on a remote device, you will see an input data object in the import folder). Once the point is used to create a remote network object on the L-Vis device, the direction will change, since a network variable output will be required to send data to the remote devices network variable input.

To simplify the selection and configuration of remote network objects for CEA709 devices, it is possible to create one device configuration template for the different program-IDs. The device template defines a set of network variable objects and their configuration, which can be used as a template when a device of the specified type is added to the project. To add new network variables to the device template, select the desired imported points from the import folder and select the context menu command *Use as Template* to add them to the respective device template, which will be automatically created for each device in the *CEA709 Templates* folder. On these templates, you can now configure a few settings like the desired data point name or the type of data point (external or static NV). These settings will be applied automatically when a point matsching the template is used on the device.

When the templates are ready, it is possible to use all data points from all scanned objects which match one of the available templates and have the default settings applied to the newly created points. To do this, select the command *Use on device and apply all templates* on the top level scan folder.

NOTE: A remote network object refers to another device in the network, which had a certain configuration at the time the scan data was collected. If the configuration of the remote device changes later on, the remote network object may stop working until the network is rescanned or the mapping to the remote device is changed manually to reflect the new configuration.

Local Scheduler and Calendar

To use scheduler and calendar functionality on the device, the appropriate data objects need to be created first, followed by a few additional configuration steps which are detailed below.

Point Creation

As the first step, the required data points must be created. Create the calendar point in the calendar folder and the required scheduler points in the scheduler folder, as described earlier in this chapter.

Calendar Point Configuration

Once the calendar point is created, attach new calendar patterns as required to describe the individual day classes, like holiday, maintenance day, and so on. Do this by using the command *Create Calendar Pattern* from the context menu of the calendar point. A new dialog appears where you can enter a name for the calendar pattern and edit the days which should belong to this day class.

When done, close the dialog using the *Create Pattern* button. Repeat this step to create all required patterns. All patterns configured here will later be available on the local schedulers for use.

Scheduler Point Configuration

To configure the local scheduler points, select the command *Configure Schedule* from the context menu of the scheduler point. The same dialog which appears when a new scheduler is created is shown and allows to configure the scheduler. Of course, this step can also be done directly when the point is created.

First, attach the data points which should be controlled by the scheduler. Switch to the tab *Scheduled Datapoints* and use the *Attach Datapoints* button to select and attach one or more data points to the scheduler.

NOTE: There may be limits in how many and which data points may be attached to a scheduler. For example, on a BACnet scheduler, only data points with compatible data types may be attached to the same scheduler object. On a CEA709 scheduler, only data points representing an entire NV may be connected, but not individual elements of a structured NV.

For each of the attached data points, one or more lines appear in the list below the attach button. If the attached point is a structure, there will be one line fir each element of the structure.

Enter a Description text in the second column of each line. This text will be shown when the user changes a value set on the device later on.

Add new value presets by entering a name and pressing the *Create* button next to the input field. For each new preset, a new column will appear in the list. In this column, enter the desired value for each of the attached points, which will be set when this value template is scheduled. The user may later edit the values for each preset on the device but cannot add new value presets unless there is only one line (one value) in the list.

If there are multiple output values which belong together, they can be grouped in order to save space on the device. For each group, the entered value is stored only once, even if there are more data points in the same group.

When done with the point and value setup, switch back to the *Configuration* tab. You should now see the list of defined value presets in a list at the top right of the window. Drag and drop presets from this list into the time table area to define the desired output values throughout the day. Days may be copied to other days using the *Copy to* button.

At the bottom left, there is a list of all available days, which consists of the seven week days which can be used to define default schedules for each day of the week, plus any additional special days defined by the local calendar. For the special days, a priority must be assigned, so that the system knows which schedule to follow on a day which is part of more than one calendar pattern.

NOTE: The priority settings are according to the underlying network technology. For CEA709, the highest priority is 0, the lowest is 126 (127 is reserved for the default weekly schedules). For BACnet, the highest priority is 1, the lowest priority is 16.

When the setup is done, save the changes and exit the configuration dialog.

Schedule Configuration Data

It is important to note that the configuration of the scheduler and calendar objects consists of two parts:

One is the point setup, meaning the number of calendar patterns, number of scheduler objects, and which points are controlled by which scheduler. This information is part of the data point setup of the project, similar to the definition of local and remote network objects. It is always in effect when the project is downloaded and it will have an influence on the static interface of a CEA709 device.

The other part is the dates entered in calendar patterns and the actual schedule of each scheduler (when the scheduler should output which value preset as well as the definition of the value presets themselves). This information is usually changed during the runtime of the device, that is, it is considered dynamic data, similar to the current value of a network variable or server object (this data is in fact the current value of such objects). Therefore, this data is not reset with every project download, since the user wants to keep the current values if possible. Only if the scheduler setup itself changed, the device will not be able to take over the current settings, since they do no longer apply.

NOTE: The scheduler and calendar configuration entered in the configuration dialogs is stored together with the project. It can also be exported to XML format or imported from XML format. Once the project itself was downloaded to the device for the first time, the scheduler configuration should usually be downloaded as well to initialize the created objects with some data. Since this is normally not wanted in subsequent project downloads, the configuration software will normally ask the user if the scheduler and calendar objects should be initialized with the configuration data from the project or not. The behavior may be changed in the *Project Settings* Dialog between *ask, always download,* and *never download*. In any case, the configuration may be downloaded and also uploaded at any time from the *Connection* menu.

System Resources

To actually implement the scheduler functionality, there are network technology dependant software modules required on the device. The scheduler and calendar data points created here will be connected to these modules and serve as the link to exchange configuration data between the user and the actual scheduler unit.

NOTE: It is important to understand that the scheduler data points used in the project are not actually the scheduler units but only serve as a link to exchange configuration information and thus control the actual scheduler, which may be located on a completely different device. The device containing the actual scheduler may even be a third party device which is compliant to the standards for scheduling defined for the respective network technology.

In case of local scheduler objects, the required scheduler units are either automatically instantiated (BACnet devices automatically create the required server objects they need to operate the scheduler) or need to be defined by the user in a separate dialog.

For CEA709 devices, the configuration software provides a *Network Settings* Dialog, where the required number of scheduler units may be instantiated and their capacity may be configured (how many time/value entries, value templates, bytes per value template, and so on). The dialog can be accessed through the *File*

menu and contains the following options and settings which are relevant to calendar and scheduler functionality of the device:

- **Enable Calendar Object:** This checkbox enables a LonMark compliant calendar object on the device. It is automatically enabled together with local schedulers, since the two are always used together.
- **Enable Scheduler Objects:** This checkbox enables local LonMark compliant scheduler objects on the device. Checking this box will automatically enable the calendar as well.
- **Number or calendar entries:** Specifies the maximum number of different exception schedules (day classes like holiday, maintenance day) supported by this calendar object.
- **Total number of date entries:** Specifies the maximum number of date definitions which may be stored by the calendar. This is the sum of all date definitions from all calendar entries. A date definition is for example a single date, a date range, or a week and day pattern (every last Friday in April).
- **Number of local schedulers:** This is the number of local scheduler objects which should be available on the device. Each local scheduler data point created in the data point manager will connect to one of these scheduler objects. There may be more scheduler objects available on the device than are actually used at a certain time. It is a good idea to have some spare scheduler objects ready, in case another scheduler is needed.
- **Number of daily schedules:** This is the maximum number of schedules supported by each scheduler object. This number must at least be 7, since a scheduler always needs to provide one schedule for each day of the week (default weekly schedule). For each special day defined by the calendar, an additional daily schedule is required to support it.
- **Entries in Time/Value table:** This is the total number of entries in each scheduler defining a value template that should apply on a specific day starting at a specific time (the time table).
- **Number of value templates:** This is the maximum number of value templates supported by each scheduler.
- **Data size per value template:** This specifies the buffer size reserved to hold the data for each value template. More data points or bigger data structures require a bigger value buffer.
- **Max. number of data point maps:** Specifies the maximum number of individual data points that this scheduler is able to control.

As can be seen from the above list, it is not easy to configure a LonMark scheduler object. There are many technical parameters which need to be set and which require some knowledge of how these scheduler objects work internally. Therefore, the configuration software provides the following mechanisms to help in choosing the right settings:

- **Current resource usage:** The absolute minimum settings required by the current project are shown in a table at the left side of the window. This data may be used to fill in the values at the right side, but some additional resources should be planned to allow for configuration changes which need more resources.
- **Auto-Set:** This button may be used to let the configuration software decide on the best settings to use, based on the current

project. Since the current projects resource usage is taken as a starting point, all schedulers and calendar patterns in the project should first be configured as required before this button is used.

- **Set Defaults:** This button will choose standard values for all settings. In most cases, these settings will provide more resources than necessary.

NOTE: It is possible to enter anything here, until the project is actually saved or downloaded. At this point in time, the software will check that the resources configured here are sufficient to support the projects configuration. If this is not the case, this dialog will automatically open so that the settings may be adjusted.

Resource allocation

On BACnet devices, there is always a direct assignment between a local scheduler point and a server object, because the two are created and deleted together. Name and instance number of the created server object for the scheduler may be set in the same way as for any other server object.

For CEA709 devices, resource allocation is more complicated. Once the required resources are configured in the *Network Settings* Dialog, the local scheduler data points will be assigned to the available scheduler objects of the device. Each new scheduler point will pick the first available scheduler object, until all objects are used. Scheduler points which cannot be assigned to a free scheduler will remain unassigned until enough schedulers are created or other scheduler points are deleted. The assignment is shown in the columns *Index* and *Object* in the point list. These are the functional block index and name of the assigned scheduler.

Deleting a scheduler data point will detach the data point from the respective scheduler object and make this object available for other scheduler points which may still be unassigned due to missing resources or which may be created in the future. The assignment of other scheduler points to their scheduler objects is not changed.

Using the Scheduler

Once the above setup is done, the scheduler is basically operational. It will immediately start to work based on the configuration data downloaded through the configuration software. However, in almost all cases it will be required to add a control to the visible part of the project, through which the schedules may be viewed and edited. For this purpose, there is a specialized type of control available, the *Schedule Control.* To use it, create a control of this type on the page and connect one or more scheduler data points to it. Please see the section about schedule controls for detailed information.

Local Alarm Server

To use a local alarm server, create an alarm server point in the folder called *Alarm*. On CEA709 devices, there may only be one alarm server for the entire device. BACnet devices support an arbitrary number of alarm servers.

There are two different types of alarming available. The current software supports one type for BACnet and the other type for CEA709 devices:

Intrinsic Reporting

BACnet devices support an alarm mechanism called intrinsic reporting. In this concept, high and low limits are specified for individual server objects and

alarms can be generated by the server object and reported to an assigned alarm server when the value of the server object exceeds these limits for a specified time period.

Other devices in the network can register for alarm updates at the alarm server object (which is a notification class object) and display the current list of alarms as well as acknowledge individual alarms.

To set up a local alarm server and assign it to server objects, the following steps are required:

- Create the needed alarm server points (more than one may be created to organize alarms into groups.
- Add alarm conditions to the server objects you want to monitor. This can be done via the context menu of the server object, using the command *Create Alarm Condition*.
- Assign one of the existing alarm servers to this condition, which is done in the same dialog where the alarm condition is specified.

Algorithmic Reporting

CEA709 devices do currently not support the mechanism of intrinsic reporting. Instead, the application needs to provide an algorithm which determines if an alarm state is reached. On L-Vis devices, the alarm generator objects described earlier in this document are used for this purpose.

To set up alarming using algorithmic reporting, the following steps are needed:

- Create the alarm server point.
- Add alarm generator objects to your project as required.
- Set up the alarm generator objects. Connect the input data points which should be monitored and use the alarm server point as the output point of the alarm generator.

System Resources

On BACnet devices, each alarm server point automatically instantiates a notification class object to handle alarm subscriptions and notifications. The object name and instance number for the object can be configured in the same way as any other server object.

On CEA709 devices, the device firmware must provide a software module to handle alarming. To activate this module, open the *Network Settings* Dialog which is accessible from the *File* menu and check the option **Enable Alarm Server**.

Using Alarm Servers

Each alarm server keeps a list of currently pending alarms, distributes them to any clients which may be connected to the server and also receives acknowledge requests from either the application or connected alarm clients.

To access the current list of pending alarms on an L-Vis device, there is a specialized control available to which alarm server and also alarm client data points may be connected. Please refer to the section about alarm list controls for more detail.

Remote Scheduler and Calendar

Adding remote access to the configuration of a scheduler and calendar which is located on another device is done by creating remote scheduler and calendar points. These points may currently only be created from data obtained by a network scan. Here are the steps to create the required points:

- Execute a network scan, as described earlier in this document.
- From the points in the import folder, select the scheduler points you are interested in and use the command *Use on Device* to create suitable remote scheduler points in your project.
- Note that any existing calendar is automatically imported as well.
- Adjust the basic settings for the newly created points, which are now available in the folder *Remote Devices*, list the object name and description. The object name will be used as the name for the scheduler, as seen on the display later on.
- For BACnet, also adjust the poll cycle, which will be used to periodically fetch the current configuration in case the remote device does not support COV subscriptions.
- For CEA709, a static NV is created to receive information from the remote device about changes to the scheduler configuration, so that the local device does not need to poll the remote device. Set a name for this NV (default is *nviSchedLink*<*number*>) and assign it to a suitable function block.

NOTE: Due to the static input NV which is required for a remote CEA709 scheduler point, adding remote scheduler points will change the static interface of the device.

On BACnet devices, the new data points can be used right away to exchange configuration data with the scheduler on the remote device. Just connect the new scheduler data point to a schedule control to view and edit the configuration of the remote devices scheduler.

On CEA709 devices, there is one extra step to take before the new data points will be operational: The new static input NV representing the remote calendar on the local device (this NV is normally called *nviCalLink*) needs to be bound to the output NV called *nvoCalLink* located in the Calendar functional block of the remote device and the new static *nviSchedLink* NVs which were created for each remote scheduler point need to be bound to the respective *nvoSchedLink* variable located in the Scheduler functional block of the remote device. The binding between the *nvoSchedLink* variable on the remote device to the *nviSchedLink* variable on the local device defines which of the scheduler data points on the local device connect to which scheduler unit on the remote device.

NOTE: In the current version of the software, you may only bind to the same device which you actually scanned and from which you created the remote scheduler points. This will be changed in future releases, so that it is possible to create a remote scheduler point even without a network scan and bind it to any existing nvoSchedLink to connect to the respective scheduler unit.

Alarm Clients

Accessing alarm server objects on remote devices is done by creating remote alarm data points. These points may currently only be created from data obtained by a network scan. Here are the steps to create the required points:

- Execute a network scan, as described earlier in this document.
- From the points in the import folder, select the alarm server points you are interested in and use the command *Use on Device* to create suitable alarm client points in your project.
- For CEA709, select the new alarm client point and adjust the name of the local NV (default name is nviAlarm_2). Also, you may assign this NV to one of the L-Vis functional blocks as required.

NOTE: Due to the static input NV which is required for a CEA709 alarm client point, adding alarm clients will change the static interface of the device.

On BACnet devices, the new data points can be used right away to exchange alarm information with the alarm server on the remote device. Just connect the new alarm client data point to an alarm list control to view and acknowledge alarms reported by the associated alarm server.

On CEA709 devices, there is one extra step to take before the new data points will be operational: The new static input NVs representing the alarm clients on the local device need to be bound to the alarm outputs of the remote device. A CEA709 device normally delivers alarms through an output NV of type SNVT_alarm_2 located in the node object of the device, therefore the new input NV on the local device must be bound to the alarm output NV of the remote devices node object.

NOTE: Even though alarm client points can currently only be created from a network scan, the resulting alarm client object has no further reference to the scanned device. All required information is transmitted over the alarm input NV, so it is possible to later bind the alarm client to any other alarm server without rescanning the network.

Standard Procedures (CEA709)

Device Integration

How a new device is integrated into your network depends on the network management tool in use and the way the configuration software is run. The available choices are detailed in the following sections.

New Device

Integration of a new device normally starts with an empty device (no project loaded). Integration of a pre-programmed device is explained further down.

NOTE: To follow the procedures in this section, make sure there is no project loaded in your device. This can be done by setting the CLEAR jumper, starting the device, and removing the jumper again. Also, if the device was previously used in another network, it is a good idea to also reset the network configuration data by pressing and holding the service button while the device boots up. This has to be done in an extra step, when the CLEAR jumper is **not set**.

The integration procedure may vary depending on the type of network variables used in the project. The following sections detail the three possible variants.

Dynamic NVs

In case your project uses dynamic NVs only, there must be a network database system which provides support for dynamic NVs. The configuration software may be run in plug-in mode as well as in standalone mode, since no complicated database updates are required in this scenario. The followings steps will be required to integrate a new device.

- Create a new device in your database using the provided device template for the L-Vis device you are using (FT-10 or IP-10L).
- Create all dynamic network variables on the device which are required for your project.
- Commission the device, so that the dynamic NVs are created and the configuration software can communicate with the device.
- Run the configuration software either as a plug-in on the newly created device or standalone using a TCP/IP or CEA709 connection. If everything worked OK, the configuration software will be able to contact the device and determine model number and firmware. Suitable data points will be automatically created for all dynamic NVs present on the device. If you have communication problems, an error message will be displayed and the procedure cannot continue until communication is possible.
- Load the project which was already prepared or design a new project. If a prepared project is loaded, the contained dynamic NV data points will be synchronized with the existing data points, based on the NV name, direction and type. If there are any data points which cannot be assigned automatically, a dialog for manual assignment will be displayed.
- Now download the project to the device. The device will restart and activate the new project. It is now ready to use.

Static NVs

Projects using static NVs have the advantage that they do not require the network management to support dynamic NVs. Also, it is possible for such projects to run in a special mode, where the device is compatible to the older CEA709.1-A network management commands, compared to the extended network management defined in the CEA709.1-B standard.

To integrate a device using static NVs, the configuration software may be run either as a plug-in or standalone. The procedure when run as a plug-in is fairly automatic:

- Create a new device in your database using the provided device template for the L-Vis device you are using (FT-10 or IP-10L).
- Commission the device, so that the configuration software can communicate with it.
- Run the configuration software as a plug-in on the newly created device and load the prepared project or design a new project.
- Download the project to the device. A warning will appear, notifying the user of the required database update. The update and the selection of a new model number are done automatically.
- After the device restarted and the database was updated, the device is re-commissioned and ready to use. Keep in mind that during the download, a new model number was selected and the project should be saved **after** the download, so that the model number in the file on the PC matches the one in the device.

If the network management does not support plug-ins or the project is downloaded via TCP/IP to reduce the download time, the device is usually first programmed standalone and then integrated using an XIF file:

- Connect to the device using TCP/IP or CEA709. The configuration software will determine the device model and firmware.
- Load or design the project, similar to the above procedures.
- Open the **Network Settings…** dialog and set the *Program-ID Model Number* to the desired value. This will be the last byte of the resulting program ID of the device. Make sure there are no other devices in the same network using the same model number but a different set of static network variables. Also, zero is reserved for a device without static NVs, so the valid range is 1 to 254.
- If required, activate the *CEA709.1-A restricted mode*.
- Download the project to the device. A warning message will appear, notifying the user that this operation will now change the static interface of the device and that the configuration software will not be able to automatically upgrade an existing device in a network database, since it is run in standalone mode. Since the device will be integrated for the first time, this is OK.
- The device can now be integrated into the network. This is usually done using an XIF file, or, if available, an 'upload from device' method, in which the network management reads the static interface directly from the device and thus requires no XIF file. If an XIF file is required, generate one using the **Export XIF…** function from the *Tools* menu and use it to integrate and commission your device.
- If the network management tool does support plug-ins and the newly created device should be configurable in plug-in mode in the future, re-run the plug-in registration for the L-Vis configuration software. The new device will be identified as an L-Vis device and the configuration software will register itself as a configuration plug-in automatically.

Static and Dynamic NVs

This is the most complicated setup, which is not available under all circumstances. Projects using static and dynamic NVs at the same time can only be integrated and maintained when the configuration software is run in **plug-in mode**. Due to limitations of the network database system, the presence of

dynamic NVs on the device will prevent a manual device integration if there are static NVs to be created, even if you don't actively use the dynamic NV points.

NOTE: If possible, try to decide on one method and use either only dynamic or only static NVs, since this greatly simplifies the integration and upgrade process. If necessary, a mixed operation is possible, but due to the required operations on the underlying database is only suggested for advanced users. If used, you are advised to **have a recent backup of your database** ready.

The integration procedure for such a project is a combination of the procedures used for a static NV project and a dynamic NV project in plug-in mode. The dynamic NVs must be created on the device in a first step, the data points in a loaded project are synchronized with the available dynamic NVs on the device and the static NVs defined in the project will be available on the device after a database update.

The difference is, that during the upgrade of the static interface all dynamic NVs will be temporarily removed from the device and the database, so that the upgrade can be executed. The removed NVs will later be recreated automatically, but they may get a different NV index assigned, so it is necessary to update the drawing of your device. Existing bindings will be saved and restored as well. If something goes wrong, restore the database from the backup or read the section about device recovery.

Pre-Programmed Device

In some cases, it may be necessary to integrate an already programmed device into a network. This can only be done with static NV projects, since dynamic NVs are stored in the network database and not the L-Vis project and are therefore not transportable from one network to another.

The procedure is basically the same as integrating a new device with static NVs using the configuration software in standalone mode. The only difference is that the first few steps were already executed by somebody and the device already contains the final project.

When pre-programming a device in this way, an XIF file should always be generated as well after the device was programmed, and this XIF file should be delivered together with the device. If this was not the case and the network management tool needs an XIF file, it may be created after the device was programmed using the following procedure:

- Run the configuration software in standalone mode and connect to the pre-programmed device for which you need an XIF file.
- Press the **Upload Configuration** button from the tool bar to upload the project which is currently stored in the device.
- Use the **Export XIF…** command from the *Tools* menu to output the required XIF file.

Now integrate the device like any other CEA709 node, using the XIF file.

If the network management tool supports plug-ins and the new device should be configurable in plug-in mode, re-run the plug-in registration for the L-Vis configuration software, so that it registers itself on the new device.

Device Replacement

This section describes the steps necessary to replace an already integrated device with a new device using the same project as the old device. Depending on the

situation, this may not be a trivial task. The procedures for the possible situations are detailed in the following sections.

NOTE: The following procedures assume that the L-Vis project file is available to the PC which runs the configuration software. If this is not the case, the project must first be uploaded from the old device and saved to a file.

Dynamic NV Projects

Devices using dynamic NVs only are relatively easy to replace, since the device may physically be replaced right away and the configuration software may then be run in either mode. The recommended procedure to replace a device using dynamic NVs is as follows:

- Physically replace the device in your network, the new device still being empty, that is, no project is loaded yet.
- Execute the standard replacement procedure of your network management tool and use the already existing device template which was installed by the configuration software. This is the same template as used to originally integrate the device, since the device does not change its static interface in such a setup.
- After the replacement, make sure that the device is commissioned, so that the dynamic NVs are created on the device.
- Run the configuration software either in plug-in mode or in standalone mode, load the project from the file and program it into the device.
- The device restarts and is ready to use.

Static NV Projects

A device with a project using static NVs only is easy to replace if it is possible to connect the new device to an IP network for programming purposes. Here is the recommended procedure:

- Connect to the new device in standalone mode, using a TCP/IP connection (requires to set up the IP settings for the new device).
- Make sure the device is empty and remove any existing project if required. This can be done through the configuration software using the command **Remove Configuration…** from the *File* menu.
- Load the project from the file and download it to the device. A warning will appear, stating that the static interface will change and that an already integrated device cannot be upgraded. This is OK, since we are changing the interface so that it will match the already integrated device.
- Once the device restarted, it is ready to use. Connect it at its final location (replacing the old device) and use the standard procedure of your network management tool to replace the device. If an XIF file is required for this operation, you may use the one which was originally used to integrate the device, or create a new one from within the configuration software.

In case it is not possible to program the new device using a standalone connection, the procedure becomes more complicated, because the device needs to be commissioned in the network to be programmed, but the device currently in the database does not match the empty device and cannot be used for this task. The following procedure is recommended in this case:

- Create a new database or network project in your network management tool, adding the PCs network interface and a new L-Vis device and connect them using a suitable channel.
- Connect the new device physically to the network interface of your PC, or otherwise make sure that the PC can communicate with the device in the new network project.
- Commission the new device.
- Run the configuration software on the empty device and program the device with the required project, as explained in the section about integrating a new device using static NVs and plug-in mode.
- The device will be programmed, the database will be updated and the device will be commissioned in your small network project.
- Decommission the device in your helper network, close it, and open the final target network, in which the device should be replaced.
- Connect the device at its original location in the network and execute the standard procedure of your network management tool to replace a device.

NOTE: In both cases, make sure that the stored project which is programmed into the replacement device has the correct model number set. This can be checked in the **Network Settings…** dialog. The number must match the last byte of the program ID of the device to be replaced. If this is not the case and the model number is not adjusted before the download, the replacement of the device may fail with an error stating that the new program interface does not match the previous program interface.

Mixed Projects (static and dynamic)

These projects are the hardest to replace, since it takes a two-step process to complete the replacement. First, the new device needs to be loaded with the project to match the static interface of the original device, then it may be commissioned in the network to get the dynamic NVs created and then the project needs to be loaded again, so that the dynamic NVs which were not available the first time can be used. The recommended procedure is a combination of the above two procedures.

- Follow the procedure to replace a device with static NVs to prepare the new device with the original project. When the project is loaded from the file, a dialog will appear and list all dynamic data points in the project, stating that they could not be found on the device.
- Finish the dialog by removing all data points listed. Since the device does not yet contain any dynamic NVs, these data points cannot be used for the moment.
- Download the modified project into the device, but **do not** save this project over your original project. Remember that it has all dynamic NV data points stripped. You may save the project to a different file, but this is not necessary.
- Now take the device and execute the procedure for replacing a device using dynamic NVs, that is, physically replace the device and continue with the procedure. If an XIF file or a device template is required for the replacement, use the same XIF which was used to initially integrate the device or use the same device template as the device to be replaced. Since the device already has a project

loaded which matches the final static interface, it will be possible to replace the device without changing the static interface in the database. Commissioning the device will create all the dynamic NVs stored in the database.

- The original project must now be loaded a second time, but this time the dynamic NV data points can be assigned to the existing NVs and the project should load without errors.

Configuration Change

This section describes the necessary procedures to change the configuration of an already integrated device. It depends on the existing project and the kind of changes done to the project, how the update may be performed.

NOTE: For all configuration changes it is strongly recommended to **first execute the download** procedure and **then store the new project on the PC** (usually overwriting the last stored project), since this guarantees that the model number stored in the file on the PC matches the model number which was automatically selected during the upgrade procedure and that in cases where the upgrade must be aborted, the device may easily be restored to the last working project, since it is still intact on the PC and not already overwritten by the new project.

Same NV Configuration

This is the easiest of all configuration changes. As long as there are no changes to either the static or dynamic NVs of the device, there are no special requirements and no special procedures to follow. The new project may be downloaded to the device through any of the available methods, where a TCP/IP connection is usually preferred.

The device will restart after the download and will be ready to operate without any further steps.

Dynamic NV Change

If the project change includes the addition or removal of dynamic NVs **without any changes to static NVs**, the following procedure is recommended:

- Execute all required changes to the dynamic NV interface using your network management software. This includes adding new NVs and removing old NVs as required.
- Once the required changes were made, start the configuration software or, if it is already running, use the **Update Data Points** button from the tool bar to read the new set of available dynamic NVs from the device. The configuration software may run in either mode for this type of configuration change.
- Load the project and modify it as required. If the project still uses some of the dynamic NVs which were removed in the first step, these will be reported and may be replaced by other data points or may be deleted all together. Do not replace them with static NVs, since this would mean a change of the static interface, which implies a different procedure.
- Download the modified project (TCP/IP is preferred due to its speed). The device will restart and be ready to use.

Static NV Change

For project changes which result in a change of the static NV configuration, certain restrictions apply regarding the way such changes may be performed. There are two possible ways to perform such a change. The automatic and recommended way is to run the configuration software in plug-in mode, as detailed below.

- If there are any changes required for the dynamic NVs on the device, perform them as the first step using your network management tool.
- Run the configuration software **in plug-in mode** on the device which is to be changed. This will automatically update the dynamic data points according to the changes which were made to the dynamic NVs on the device.
- Load the current project from a file or from the device and modify it as required, adding or removing static NV data points. During the load, the data points used in the project are updated according to the new set of dynamic NV points. If dynamic NVs were removed or renamed, the affected data points need to be manually assigned to other NVs or may be deleted from the project.
- Download the new project to the device. A warning appears, stating that this will change the static interface of the device and that the database needs to be updated to reflect these changes.
- The configuration software will execute all required steps automatically, temporarily removing all dynamic NVs and all bindings to guarantee a correct update of the device. Once the device restarted and the database was updated, the NVs and the bindings are restored.
- The device is then commissioned and ready to operate.

WARNING: It is dangerous to change the static interface while using dynamic NVs, due to the fact that all dynamic NVs must be removed in order to upgrade the static interface. If something goes wrong during this process, all dynamic NVs on the device may be lost and must be recovered using another procedure. You are advised to **have a recent backup of the database** ready, in case the recover mechanism built into the configuration software fails as well.

For network management systems which do not support plug-ins, the new project must be loaded in standalone mode and a new XIF file must be generated after the download completed. The network management tool itself must then provide a way to upgrade the static interface of the already integrated device and take over the existing bindings. The recommended procedure is as follows:

- Run the configuration software in standalone mode and connect to the device, preferably using a TCP/IP connection.
- Load the current project from a file or from the device and modify it as required, adding or removing static NV data points.
- Download the new project to the device. A warning appears, stating that this operation will change the static interface and that the configuration software will not be able to automatically upgrade your device in the network.
- In case you are connected over CEA709, another warning will tell you that the connection will be lost after the download, because the device will go unconfigured due to the static interface change. It is therefore recommended to use TCP/IP for the connection.

- After the device restarted, use the **Export XIF…** function from the *Tools* menu to generate a new XIF file, matching the new configuration of the device.
- Execute the standard procedure of your network management tool to replace the old device with a new device and use the new XIF file to define the new interface.

NOTE: The above procedure assumes that there are **no dynamic NVs** present on the device. Manually changing the static interface of a device is not supported by any of the common network management tools, when there are dynamic NVs present at the same time. Therefore, updates to the static interface in mixed projects can only be done in plug-in mode.

Configuration Recovery

This section describes procedures to recover from situations where the current configuration of the device does not match the current definition of the device in the network. This may happen as a result of a failed upgrade procedure or because the definition of the device in the network changed because the network had to be restored from an older backup.

Basically, there are two ways to resolve any such conflict:

- Change the configuration of the device to match the current definition in the network.
- Change the definition of the device in the network to match the current configuration.

The decision depends on the desired end result, that is, if the current network definition or the current device configuration is closer to the desired end result.

Change Device Configuration

In case the current definition of the device in the network represents the desired end result, the configuration of the device should be set back to match the definition in the database. This of course is only possible if a matching project is still available as a file on a PC. Assuming that a suitable project file is available, the device may be easily restored by following the appropriate procedure for a device replacement, as outlined earlier in this document.

To determine if a project is suitable or not, it is not necessary to execute the whole replacement procedure just to find out that the result still does not match the definition of the device in the database. Instead, check the following things upfront, before starting the download:

- Run the configuration software standalone, without connection to any L-Vis device and load the project which is considered to match the current device in the network.
- Check the program ID of the device definition in the network.
- If the ID starts with `9000a9`… then the interface matches a standard device, without any static NVs. In this case, only consider projects which do not contain any static NV data points. The loaded project must have a Program-ID model number of 0.
- If the program ID starts with `9000d7`… then the device has static NVs created and therefore uses a non-standard interface. In this case, check the last byte of the program ID. It is the program ID

model number and it must match the model number of the project which you consider for download.

- Once a project with matching model number was identified, this will most likely be compatible as far as the static interface is concerned. To double check, you may go through the list of static NVs defined in the project and compare it with the NVs that should be available on the device according to the devices definition in the network. If the static interface seems to match, the replace procedure may be started.
- During the replace procedure, if the selected project causes data points to be reported during project load, which cannot be assigned to any of the existing dynamic NVs, then this project assumes a different set of dynamic NVs and is most likely not the right version of the project. Repeat the process with other projects. The only time when such reports are to be expected is during the first download in a two-stage replace procedure, as required for mixed projects (static and dynamic NVs).

Change Network Configuration

There are a few cases where the network definition of the device is changed to match the current configuration of the device. Such changes are normally handled by the network management program, but may be supported by functions of the configuration software as well.

While changing the device configuration requires one of the device replacement procedures to be executed, changing the network configuration usually means to restore a database backup which matches the configuration of the current device.

If the device uses static NVs only and the bindings which were originally used together with this project were saved and are available in a file, the network configuration may be adjusted by completely removing the old device definition (if any), executing the integration procedure for a pre-programmed new device, followed by a binding import to restore the original bindings.

Recover from a failed Update

When a project update including a change of the static interface fails, there may be some extra steps necessary to restore the last working setup or to resolve the original problem and finish the upgrade. Which one to use depends on how far the upgrade procedure ran.

Failure before Database Update

If the procedure failed before the database update, that is, the device template in the database is still the old version, the device must be rolled back to the last project as well, so that the database and the device match again. The recommended procedure is detailed below:

- Follow the standard procedure for device replacement as appropriate for your project, but **do not run the configuration software in plug-in mode at any time.** Only use the software standalone, including any other configuration tasks you may be doing to other devices at the same time. If the project used static and dynamic NVs and the upgrade required a change of the static interface, your dynamic NVs may be lost and the replace procedure may report data points which cannot be assigned. Remove them from the project and continue.

- Once the device is replaced and commissioned, run the configuration software in plug-in mode.
- If the device lost its dynamic NVs, use the function **Recover DynNVs…** from the *Tools* menu now, to recover the set of dynamic NVs which were removed during the last upgrade.
- Most likely, the bindings will be lost as well. Use the function **Recover Bindings…** from the *Tools* menu to recreate the bindings as they were recorded before the upgrade procedure started.
- If the replace procedure reported missing dynamic NVs before, the project has to be loaded again. Clear the current project data from the editor and re-open it from the project file.
- Program the device to restore the system to the last working state.

Failure after Database Update

If the procedure failed after the database update, that is, the device successfully loaded the new project and the database was updated to match the new static interface, the only things which could still be missing are dynamic NVs and bindings which would need to be restored after the database update.

There are two possible options from here:

- Try to find the reason why the NVs or the bindings could not be restored, possibly checking the **Binding Report…** which is available from the *View* menu for errors, then try to use the **Recover DynNVs…** and **Recover Bindings…** functions from the *Tools* menu to first restore the dynamic NVs (if any) and then restore the bindings.
- Revert back to the last working setup by removing the device from the network database and roll back the device configuration by following one of the procedures for integration of a new device, but using the last working project. While doing this, **do not run the configuration software in plug-in mode at any time.** Also, skip the step of manually creating dynamic NVs, if instructed to do so by the standard procedure. If the old project actually used dynamic NV data points, these will be reported as unusable. Delete them from the project and continue. Once the device is re-integrated, recover the dynamic NVs (if any) and the bindings as described above. If dynamic NVs were recovered, the project needs to be loaded again so that the NVs can be used.

NOTE: Reverting back to the last working setup is much easier if a backup of the database is available. In this case, first restore the database from the backup and then simply follow the appropriate procedure for device replacement, using the last working project file. In this case, the configuration software may also be used in plug-in mode during the replace procedure, since the recover functions are not required.

Special Functions (CEA709)

Binding Management

When the configuration software is run in plug-in mode, additional functions to export, import, and remove the network bindings of the device are available from the *Tools* menu.

The **Export Bindings…** function scans the database and outputs all current bindings into a text file in CSV format. This file may be viewed in a text editor or spreadsheet program and used for documentation purposes or as a security backup before major changes are done to the device.

The **Import Bindings…** function reads a file which was previously created by the export function or manually created in a text editor and creates all the bindings which are listed in the file.

NOTE: If you use a network management tool with a graphic representation of your network bindings, you will need to update the drawing based on the modified database, so that the new bindings created by the configuration software become visible. This is normally not required for object oriented tools, where the new bindings immediately appear in the object tree.

The **Remove Bindings…** function is not normally used, but may be helpful if the network bindings of the device should be reworked completely without deleting the device itself.

NOTE: This function is also useful for the rare cases where the static interface of a device needs to be upgraded manually and the network management tool has difficulties to take over the existing bindings during the upgrade. In this case, export the bindings, remove them, then do the manual upgrade and as the last step restore the bindings from the file.

XIF Export

When the selected model is an CEA709 model and the current project uses at least one static network variable, the menu item **Export XIF…** becomes available in the *Tools* menu. This can be used to create an XIF file for the current project, for later device integration. This is normally used when the network management software cannot run the configuration software in plug-in mode and the device must therefore be integrated manually, after it was programmed outside the network management with the configuration software running in standalone mode.

To generate an XIF that matches the actual device, there are two options:

Offline

A project may be designed completely offline, without any connection to a physical device. The target device type and firmware version are selected from the menu. In this scenario, the following extra steps are necessary:

- **Select Model Number:** Since the project is never downloaded to a device, the model number is not set automatically. Before exporting the XIF file, open the **Network Settings…** Dialog from the *File* menu and enter the desired model number for your device.
- **Select Transceiver:** Since no device is connected, the configuration software cannot automatically determine the transceiver used. Therefore, a dialog will appear and ask for the transceiver type which will be used by the device.

When the project for which this XIF file was created is later actually downloaded into a device, make sure to use the same model number as you entered before the XIF was exported.

NOTE: If the device already contains a project using the same model number, but the static interface of this project does not match the new project, the configuration software will automatically change the model number and the result would no longer match your XIF file. In this case, remove the incompatible project first and then download the new project.

Online

In cases where the project is designed online (while connected to a device), all required data can be determined automatically. To make sure that the model number in the XIF file matches the model number which is automatically selected during project download, first download the finalized project to your device and then export the XIF file.

CEA709.1-A Operation

The CEA709 models normally support the CEA709.1-B standard, which means that the device accepts the extended network management commands used to configure the extra resources available on such devices (for example up to 512 address table entries on L-Vis). However, since the standard requires devices which were once configured using extended network management commands to no longer accept any of the older commands, such a device would no longer be usable together with older management software, which does not provide support for the extended command set.

To guarantee that the device will be usable together with older tools, the **Network Settings** dialog which is accessible from the **File** menu has a checkbox to enable a so called *CEA709.1-A restricted mode*. In this mode, the device will not accept any of the extended commands and react according to the old standard. This also means that the device is limited to 15 address table entries.

Dynamic Network Variables

Some of the installation scenarios for CEA709 L-Vis devices make use of dynamic network variables. This section gives a short description of how dynamic network variables are created in different network management tools.

LonMaker® Network Management Tool

To create a dynamic network variable, create a functional block (e.g. L-Vis1) for the device as shown in Figure 7.

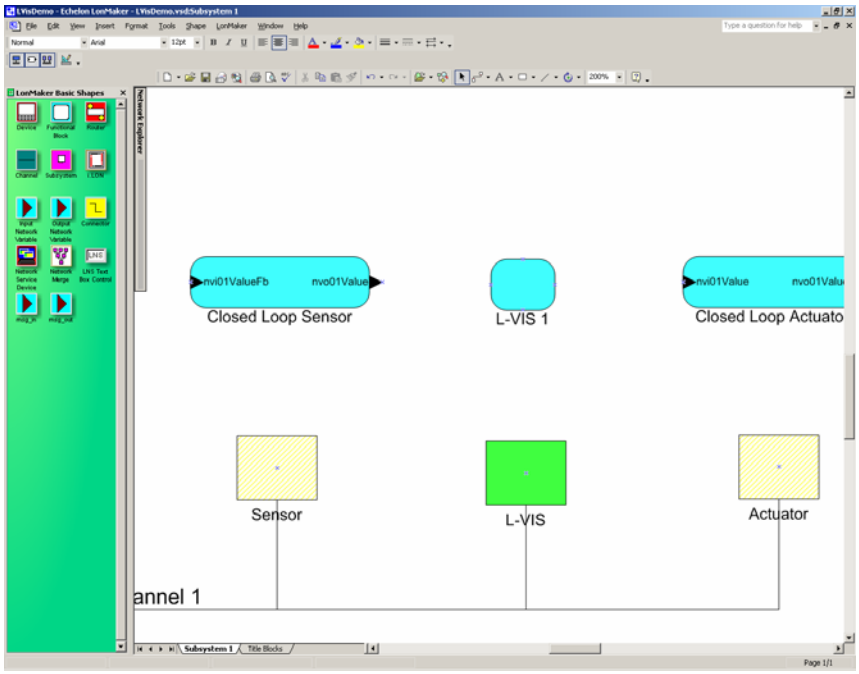


Figure 7: Create a function block

Drag a input or output network variable shape from the LonMaker® network management tool shape sheet and drop it on the function block. The dialog in Figure 8 is shown.

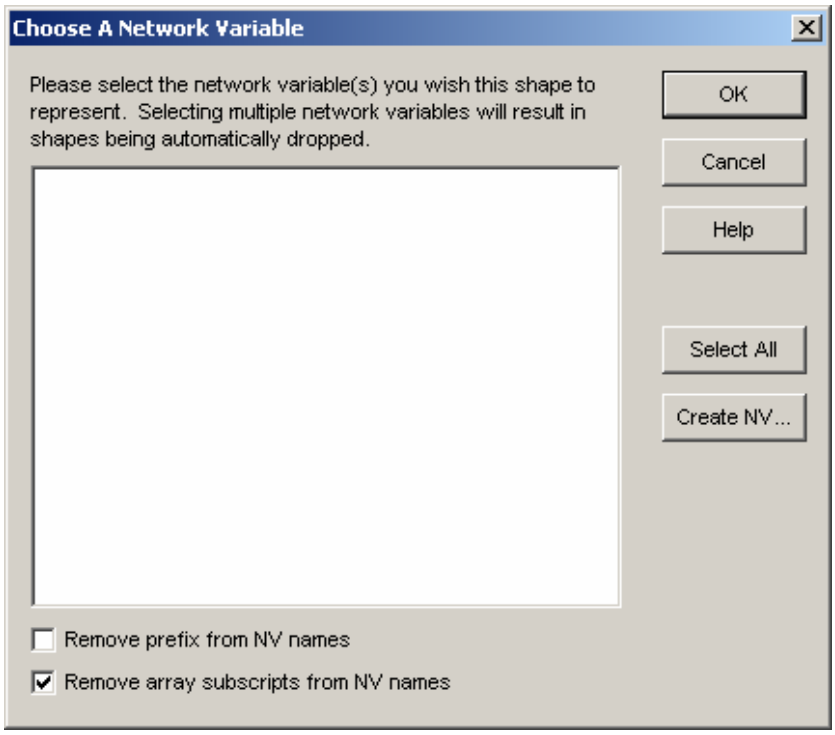

Choose A Network Variable
Please select the network variable(s) you wish this shape to represent. Selecting multiple network variables will result in shapes being automatically dropped.
OK
Cancel
Help
Select All
Create NV...
Remove prefix from NV names
Remove array subscripts from NV names

Figure 8: Choose network variable dialog

Select 'Create NV' and in the displayed dialog (Figure 9), enter the name for the new network variable and click on 'Browse".

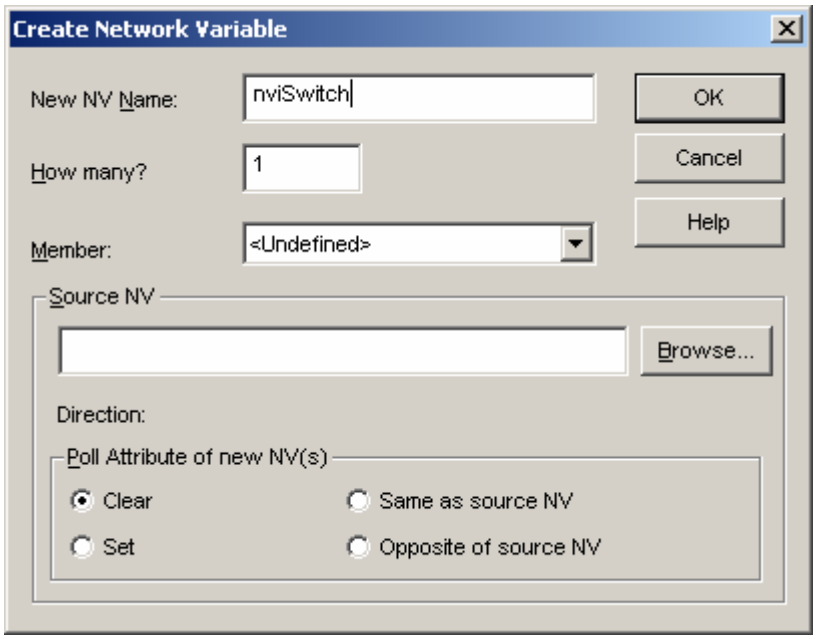


Figure 9: Create network variable dialog

In the dialog (Figure 10), select the network variable on the node to which the new dynamic network variable will be connected afterwards. The dynamic network variable will get some attributes of the selected variable, like the SNVT type, assigned. Click on OK to confirm your choice.

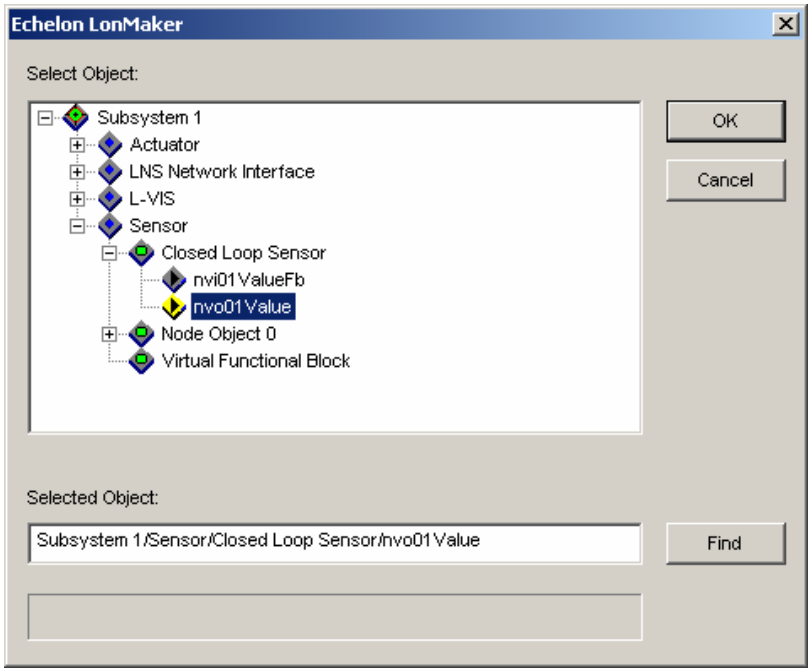


Figure 10: Select complementary variable dialog

Now the source NV name in the Create Network Variable dialog is filled in (Figure 11). Set the poll attribute for the new dynamic network variable. When Finished, press the OK button and also confirm the Choose a Network Variable dialog with OK.

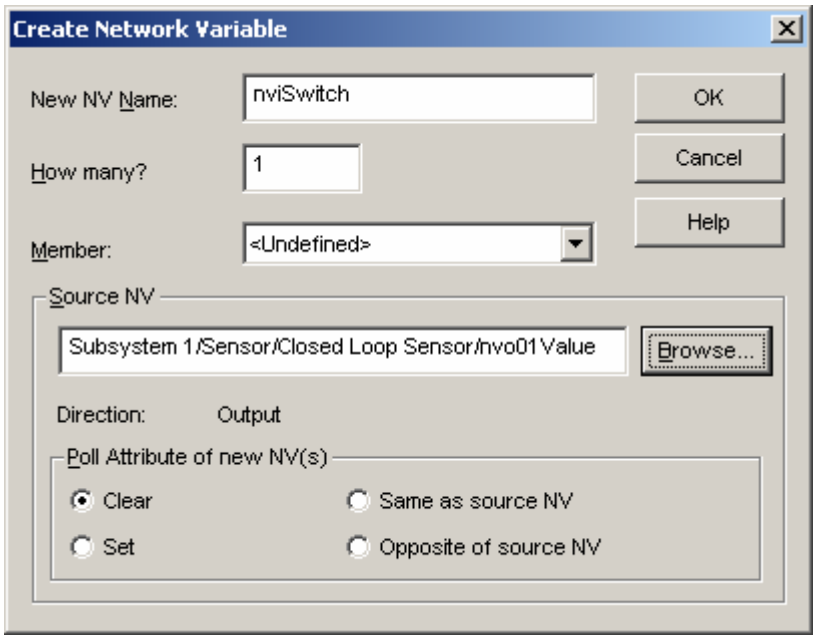


Figure 11: Create network variable dialog

This completes the creation of the new dynamic network variable (Figure 12). The dynamic network variable can now be bound to other network variables like a normal network variable and can also be used as a data point source or data point sink in the L-Vis configuration software.

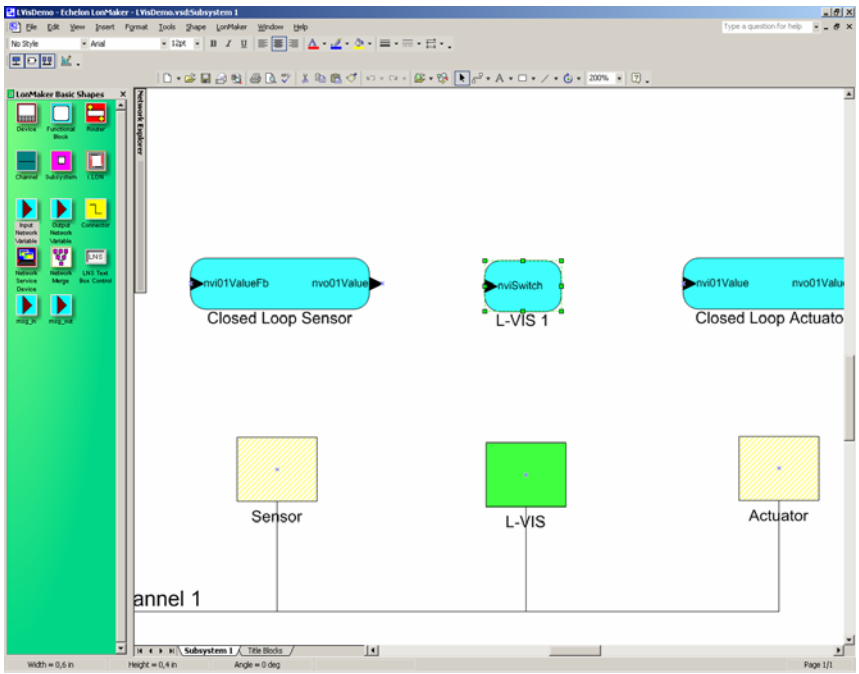


Figure 12: New dynamic network variable

NL220

To create dynamic network variables in NL220, add the L-Vis device to your project. In the context menu of the L-Vis device, go to **Virtual interfaces** and select *New interfaces*. Enter a name for the new virtual interface (e.g. L-Vis 1) and click on *OK*. Figure 13 shows the L-Vis device with the new virtual interface.

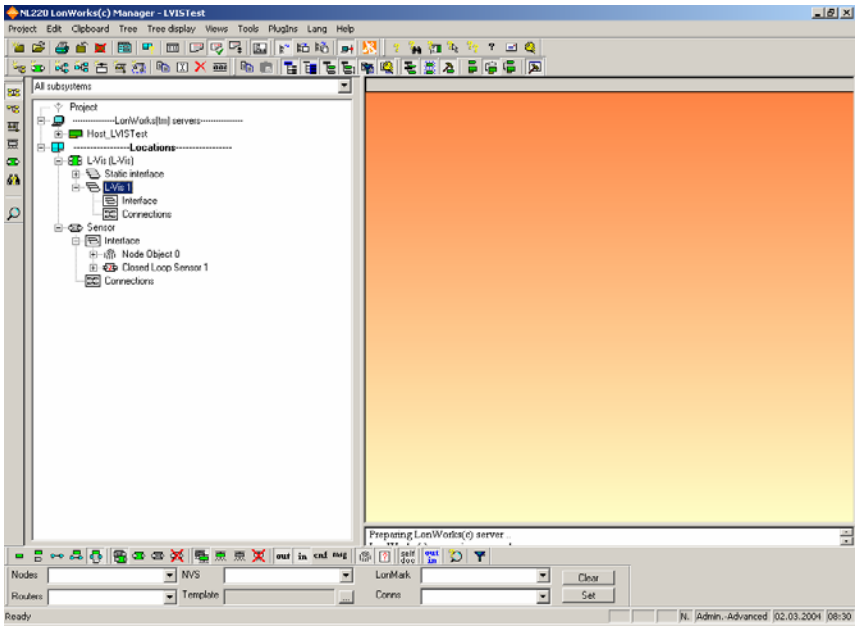


Figure 13: Create new virtual interface

To create a new dynamic network variable, go to the node which holds the complementary network variable of the new dynamic network variable to be created. The new dynamic network variable will use some of the properties of the complementary network variable (e.g. SNVT type). Drag the complementary network variable and drop it on the **Interface** object of the virtual interface. In the dialog (Figure 14), enter a name for the new dynamic network variable and set the direction and the poll attribute. When done, click on *OK*.

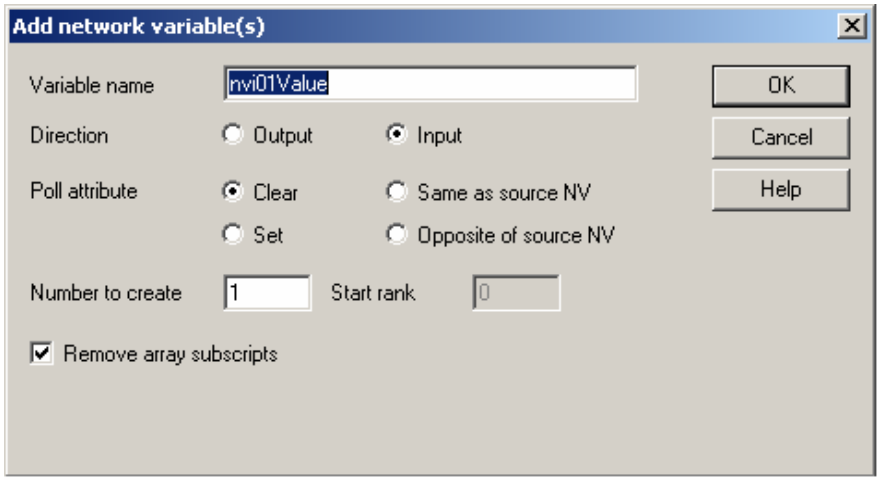


Figure 14: Add network variable dialog

This finished the creation of the dynamic network variable and shows the window which allows to bind the dynamic network variable to the complementary network variable (Figure 15).

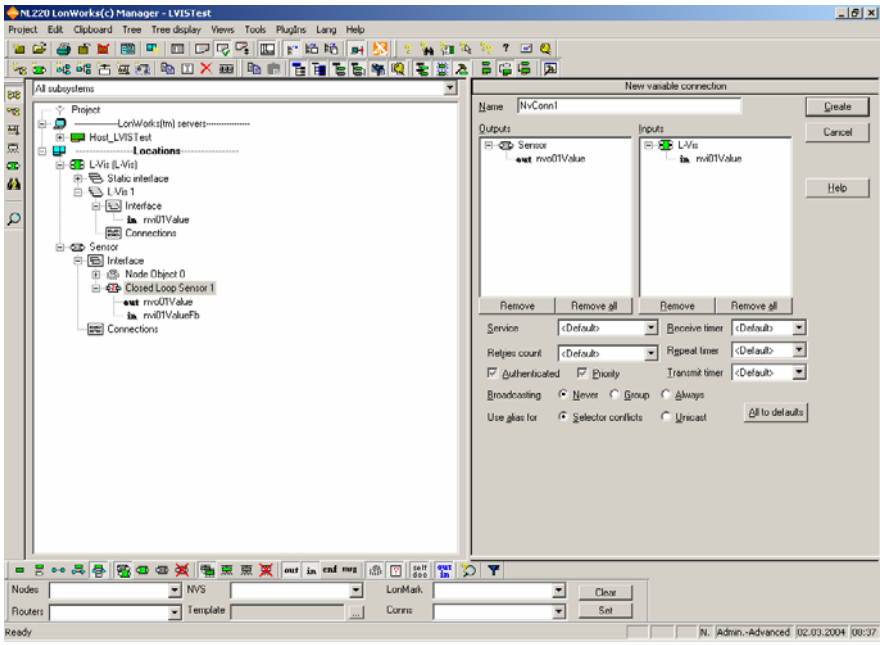


Figure 15: Network variable connection window

Alex

To create dynamic network variables in Alex, add the L-Vis device to your project. Select **Virtuelle Funktionseinheiten** and click on *Neue Virtuelle Funktionseinheit* (Figure 16).

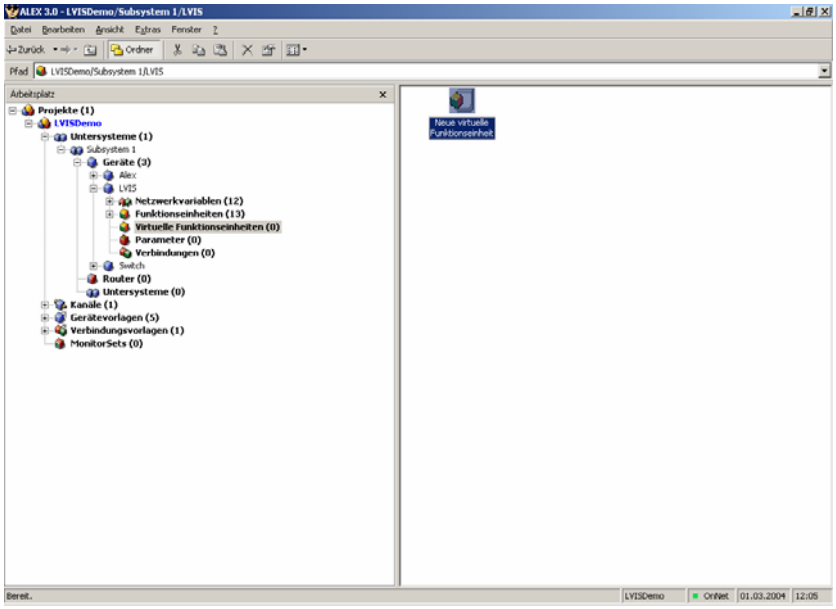


Figure 16: Alex main window

Enter a name in the dialog (Figure 17) and press *OK*.

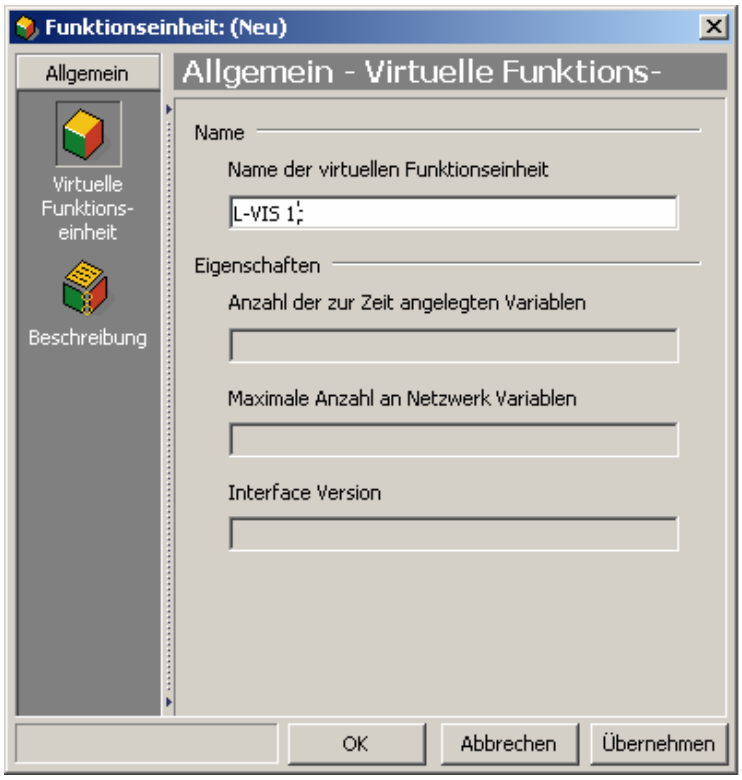


Figure 17: Virtuelle Funktionseinheit dialog

Open the Netzwerkvariablen collection in the tree view and select *Neue Netzwerkvariable* (Figure 18).

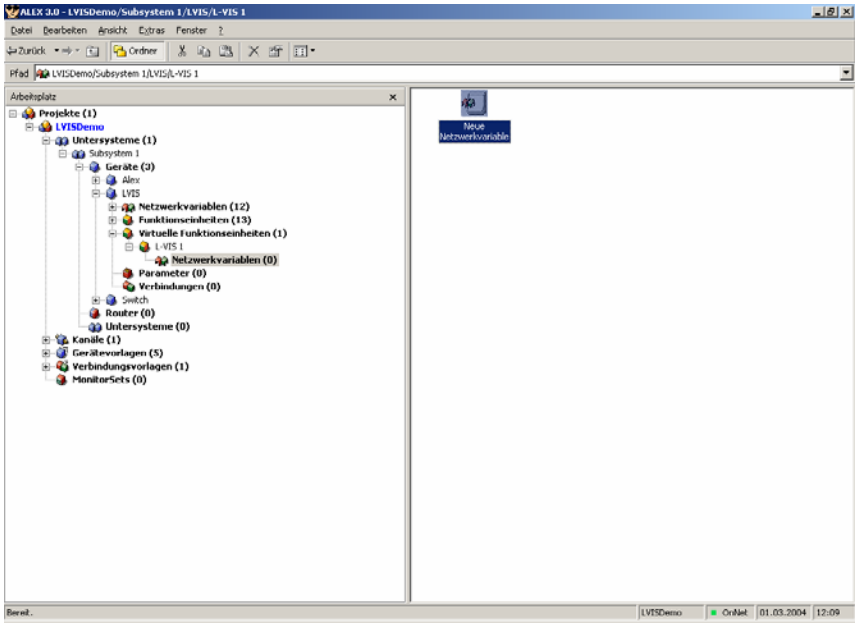


Figure 18: Create new network variable

In the Netzwerk Variable dialog (Figure 19), select the device template (Gerätevorlage) and the network variable to which the new dynamic network variable will be connected.

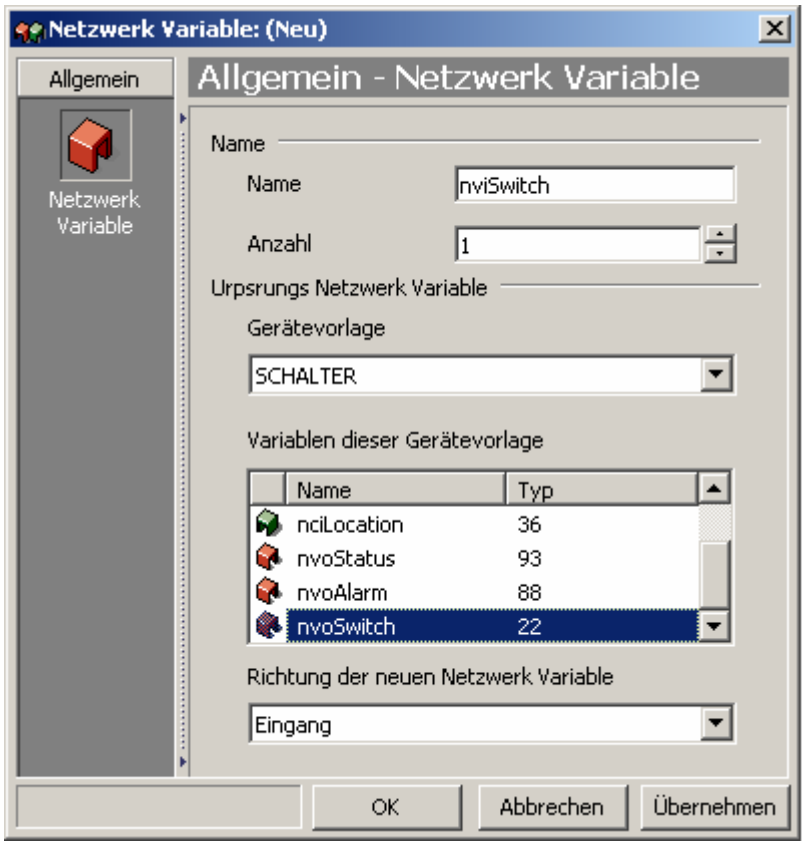


Figure 19: New network variable dialog

The dynamic network variable will get attributes like the SNVT type from this network variable. Select the direction of the new dynamic network variable and enter a name for the network variable. Finally, click on *OK* to confirm the creation of the new network variable (Figure 20).

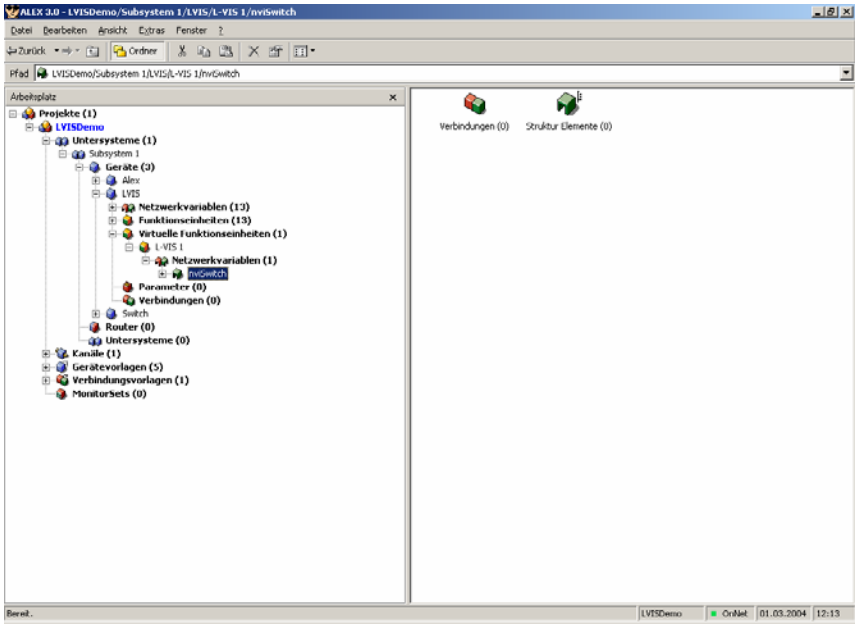


Figure 20: Finished creation of new network variable

Built-in LONMARK® Objects

The CEA709 models of L-Vis provide a number of static function blocks which are available for use, even when no project is loaded. These blocks are described in the following sections.

Timer Object

The timer object implements a LONMARK® Real Time Keeper object according to the LONMARK® Functional Profile #3300. It sends out the current time in the nvoDateTime network variable of type SNVT_time_stamp. The object is configured using the standard configuration properties:

- SCPTmanualAllowed
- SCPTmasterSlave
- SCPTobjMajVer
- SCPTobjMinVer
- SCPTsummerTime
- SCPTupdateRate
- SCPTwinterTime.

The configuration properties are defined in the LONMARK® functional Profile #3300 document.

Switch Object

The switch object implements a LONMARK® Switch object according to the LONMARK® Function Profile #3200. It sends out an nvoSwitch network variable of type SNVT_switch and receives a feedback over nviSwitchFb. The object is configured using the configuration properties

- SCPTmaxOut
- SCPTmaxSendTime
- SCPTminSendTime
- SCPTstepValue
- SCPTtimeout.

The configuration properties are described in detail in the LONMARK® Function Profile documentation.

On L-Vis, the switch object is controlled by a switch or push button connected to the *Switch* terminal IN0 of the device. The object can operate in 3 different modes:

1. **Switch mode**: Use this mode when a two position switch is connected to the input terminals. To select switch mode, set SCPTstepValue and SCPTtimeout to zero.
2. **Push button mode**: Use this mode when a push button is connected to the terminals and you want to toggle the light on and off with each push of the button. To select push button mode, set SCPTstepValue to zero and SCPTtimeout to a value greater than zero
3. **Dimmer mode**: Use this mode when a push button is connected to the input terminals and you want to use the button to toggle the light on and off with each short press of the button and ramp the light intensity up and down when holding down the button. To select and configure

dimmer mode, set SCPTstepValue to the amount of change wanted for each step when ramping up or down and set SCPTtimeout to the desired maximum push time, which is detected as a short press (the time to wait before starting to ramp the light intensity up or down). The speed at which value updates are sent out during ramping is controlled by SCPTminSendTime.

Relay / LCD Backlight control

The relay object implements a LONMARK® Lamp Actuator object according to the LONMARK® Functional Profile #3040. It receives the input value of type SNVT_switch in the variable nviSwitch and sends out a feedback of the current state in nviSwitchFb. The output network variable reflects the state of the relay input of the old LVIS-3ECTB device. The newer touch screen models do not provide a relay and the lamp actuator object on these models is used to control the LCD backlight.

To overrule the value which is adjusted in the L-Vis Plugin Software, the state part of the nviSwitch network variable has to be set to 1. In that case, the value part of the network variable controls the brightness of the display from 0 to 100%. If the state part of the variable is set back to 0 again, the backlight automatically uses the values which are adjusted in the L-Vis Plugin software. This feature can be used to adjust the backlight in relation to the ambient brightness, which could be measured with a sensor.

On newer firmware revisions, the backlight may also be controlled via an internal system register, which is available as a data point and may be used freely across the project. This is the preferred way of controlling the backlight.

HVAC Temperature Sensor

The temperature object implements a LONMARK® Temperature Sensor object according to the LONMARK® Functional Profile #1040. It sends out the current temperature in the nvoHVACTemp network variable of type SNVT_temp_p. The object is configured over the configuration properties

- SCPTmaxSendTime
- SCPTminDeltaTemp
- SCPTminSendTime
- SCPToffsetTemp.

The configuration properties are described in detail in the LONMARK® Functional Profile specification.

On the L-Vis device, the temperature sensor object reads the current temperature value from an external temperature sensor connected to the input terminals labeled 'TEMP' on the device.

The same temperature is also available via a system register, which is the preferred way to read the temperature if it is used directly on the L-Vis device.

Advanced Topics

Project Settings

Using the command *Project Settings* from the *File* menu, a number of advanced options can be controlled which apply to the entire project. The dialog is organized in a number of sections, which are explained below.

Page Protection

In this area, all options related to access control can be configured. The following data can be set:

- **Setup PIN Codes:** This button opens a new dialog where the 16 available access levels can be configured. For each level, a name and a PIN code can be entered, except for level 0 (the lowest level) which cannot be protected.
- **Next download sets PIN codes:** If this checkbox is selected, the next project download will reset the PIN codes stored on the device with the codes entered in this project. Otherwise the PIN codes of the devices are not modified. PIN codes can be changed on the device during runtime by writing new PIN codes to the PIN code Set system registers.
- **Lock open pages after:** This sets a timeout after which the system resets the current access level back to 0, if no user input was detected (auto-logout).
- **Go to default page after:** This sets a timeout after which the system will switch back to the page marked as the default page, if no user input was detected.

Timeout Values

This section is used to define various time limits. The meaning of them should be clear from the description of the parameter.

System Flags

The following system flags are currently available:

- **Lock pages in setup menu:** If this option is checked, the pages of the built-in system setup menu will be protected at level 15, otherwise they will be public. If the default setup menu is not used, this option has no effect.
- **Hide setup menu:** This option instructs the device not to add a link to the built-in setup menu, so that the built-in setup is not accessible. The user may provide customized setup pages instead,

matching the local language and the design of the other pages. See the section about custom setup menus earlier in this document.

- **Disable touch gestures:** This option causes the touch gestures to flip pages and open the setup menu to be turned off.
- **Ignore data point value state:** This is a compatibility option which will be checked automatically when an older project is loaded. Turn it off to enable the new feature of tracking the state of a data point in addition to its value. For example if an input NV has a receive timeout set and does not receive a value, the point will go OFFLINE and the display will indicate that the value shown is no longer considered valid. Note that using invalid values in a formula will automatically invalidate the result, therefore it is possible to turn state tracking off for individual data points (see the description of the data point object). The checkbox here is a master switch to turn state tracking off for the entire project.

Remote Access

The option **Enable VNC Server** may be checked to enable a built-in VNC server on the device, if supported by the firmware (version 3.0.0 or newer). To use it, a TCP/IP connection to the device must be possible, since VNC is a TCP based protocol. The remaining options are used to set the TCP port on which the VNC server should listen for incoming connections, the maximum number of simultaneous connections that the server should accept and an optional password to protect access to the device.

A device with a firmware supporting VNC which has no project loaded will automatically enable a VNC server on port 5900 and accept one connection without password. This can be used to simplify device installation. If a fresh project is started, the VNC option is turned off by default.

To connect to the VNC server, install one of the available VNC clients on your PC or other device (VNC clients are available for PDA and even some cell phones) and connect to the device. You can then remotely access the LCD display of your device and use the mouse to operate the touch screen.

If more than one user is connected to the same device, everyone will see the same display, just like VNC used on a PC.

NOTE: The display of L-Vis currently uses a VGA color map (256 colors). It is therefore most efficient to transfer the color map to the client and then only transmit the color index for each pixel (one byte per pixel). If the VNC client supports this mode (color map mode), the VNC server on the L-Vis device will tell the client that this is the preferred display mode to optimize speed and bandwidth usage. However, many clients only support true color modes, where either two or more bytes per pixel need to be transferred or the color resolution will be reduced. A client which supports color maps is RealVNC.

Sound

This section controls the sounds produced when touching the display and entering values. The frequency of a low pitch and a high pitch sound may be entered and the sound output can be turned on and off.

OEM Bitmaps

In this section, bitmaps can be specified to customize the about page (shown during system boot) and the PIN code entry page (shown when a protected page is accessed and the current access level is not sufficient). The bitmaps must

match the resolution of the display (320x240). Suitable template bitmaps are installed together with the configuration software.

System Colors

This section is used to adjust the general system colors. They will be used on the device by elements which are created dynamically, for example the keypad, and will be used by the configuration software as default colors for new objects when no other defaults are set by the user (using the button *Set as Default*) on the **Common Properties** page.

System Settings

The settings which can be made in this section are:

- **Device Name:** A device name can be given using this field. It will be used as the host name when the device requests an IP address at a DHCP server and it will be used as a server name by the built-in VNC server. The device name will also be available on the device in a system register, so it can be displayed or connected to other data points so that it can be seen on the network.
- **Time Source:** This dropdown list allows to set a specific source for time synchronization. This avoids possible conflicts if there is a time signal coming in from more than one source and the time is not the same. Select the desired source for time synchronization from the list.
- **Update Scheduler Config:** This dropdown list is used to set the behavior of the configuration software when a project was downloaded to the device or uploaded from the device and there are local schedulers configured. Depending on the setting here, the configuration software will either automatically synchronize the scheduler configuration data, ask the user if the configuration should be updated, or not update the configuration, in which case the user may manually update using the commands from the connection menu.
- **Keypad Button Size:** Specifies the desired size of the keypad buttons on the display (width x height) in millimeters.

Data Access

To access trend and event logs created by the respective controls, a dedicated FTP access is available. Using the user name and password specified here, it is possible to log in using an FTP client and download the required data friles.

LCD Backlight

This slider is used to set the brightness of the LCD backlight when the unit is active. Good settings are between normal and bright, where the bright setting consumes more power. The life time of the backlight is not significantly affected by the brightness setting.

System Strings

Pressing the button *Setup System Strings* opens another dialog, where a number of strings can be translated to match the requirements of the project. These strings are used by the specialized controls on the device to edit schedules, calendars or display alarm lists. A set of translations may be given a name in the

Preset field, which can then be saved using the *Add* button. The translation is then stored on the system and will be available in the Preset dropdown list for re-use in other projects.

Access Control

Access control is organized in 16 levels. Pages and input controls can be assigned a minimum access level required to view the page or enter data on an input control. Any access level higher than the specified minimum level automatically grants access to the protected object.

To reach a specific access level, there are a number of possible options:

- Switching to a page which cannot be viewed at the current access level will automatically bring up a system page where a PIN code can be entered in order to increase the access level and access the page.
- On a normal project page, a numeric input control can be placed to allow the user to write a PIN code value to the system register called *PIN Code Enter*. Any value written to this register will be interpreted as a PIN code and the system will try to log the user in using this code. If none of the defined access levels has a matching PIN code, the access level is set to 0 (log out). To construct a suitable control, make sure to set the input value range to 0000-9999 and check the *Password Input Keypad* option.
- Using a data point connector, a PIN code can be received from the network and forwarded to the *PIN Code Enter* register to allow remote login using a PIN code.
- The desired access level may be set directly by writing a value between 0 and 15 to the system register called *Access Level*. This is less useful if allowed from a control on a project page, but may be convenient if there is an external access controller in the network, where the user was already authenticated (for example using an RFID card). The access controller can communicate the successful authentication over the network to the L-Vis device, where a suitable access level can be set directly, without using a PIN code.

For security reasons, it is possible to change the PIN code for each level by writing the new PIN code to the respective *PIN code Set* register. There is one register for each of the access levels 1 through 15. The new PIN codes will be stored on the device and remain in effect until a new project is loaded with a special option set, telling the device to reset its PIN codes to the values stored in the project.

Remote Network Interface

On newer hardware of the CEA709 model, there is support for remote network interface functionality, similar to that of a NIC-IP. The function is only available if the device is operated in FT-10 mode (not IP-852 mode) and only if the hardware can support it. If active, the device accepts connections from a PC on the TCP/IP interface and can act as a remote network interface, providing access to the FT-10 channel to which the device is connected. It also provides functionality to run the LPA software on this interface to monitor the FT-10 channel.

NOTE: Using this feature will cause additional load on the device, which should be considered at the time of project design. If the project already requires a lot of CPU time to run, it may not be feasible to use the same device as a remote network interface at the same time.

The current state of the RNI module is available in a system register called *RNI State*. It may be used to make a running RNI connection visible on the display, as a warning message or other element to alert the user.

Device Model and Firmware

When the configuration software is started in standalone mode and is not connected to a device, the *Model* menu can be used to select the model for which a project should be created and the *Firmware* menu can be used to select the firmware version of the intended target device. This enables the user to create or edit a project, which is intended to run on an older firmware version, even when the firmware version to use cannot be queried from the device. The real time LCD preview is automatically adjusted to match the behavior of the selected model and firmware version, so that the preview is always accurate down to the pixel level (what you see in the preview is exactly what the device will display, pixel by pixel).

When started as a plug-in or connected via TCP/IP or CEA709 in standalone mode, the menu items to select model and firmware version are grayed out, so that the firmware version cannot be arbitrarily changed by the user. The menu items or the correct model and firmware version, as reported by the device, are automatically checked. The real time preview of the LCD is automatically adjusted to reflect the behavior of the reported firmware version and the project is saved in a format readable by the firmware of the connected L-Vis device.

The configuration software is always backwards compatible to older firmware versions, so that it is possible to use newer configuration software with older devices. Also, the devices are backwards compatible to older project versions, so it is possible to use older configuration software with newer devices as well.

NOTE: When using older configuration software to connect to newer devices, the software will not recognize the firmware version reported by the device, since this firmware was not available at the time the configuration software was built. In this case, the software will output a warning and save the project in the most recent version it knows. This will be readable by the device, due to the devices backwards compatibility to older project files, but you may not be able to use all features and the LCD preview may not accurately reflect the behavior of the device. It is therefore suggested to first upgrade the configuration software and then upgrade the devices.

The firmware of the L-Vis device can be upgraded as newer firmware versions become available. To find the current firmware version of your device, use the *Device Info…* menu item in the *View* menu, which will be enabled when the software is connected to a device or go to the About Page on your device.

To upgrade the device with a new firmware, select the *Upgrade Device…* menu item from the *Firmware* menu, which will be available when connected to a device.

NOTE: While older versions of the firmware also allowed to upload the current firmware from the device, this is not possible anymore in current firmware versions, due to technical limitations. It is therefore suggested to keep a copy of the downloaded firmware somewhere on a PC, in case the device needs to be set back to this version at a later time.

Avoiding Update Loops

Especially when a lot of data point connectors and mathematical objects are used in a project, the danger of accidentally creating update loops increases and the user needs to be aware of this problem.

An update loop means that a single update of one data point causes a chain of following updates which does not end, because one of the following updates again triggers the original update. For example, register A is used as input for a mathematical object which writes its result to register B, while at the same time the value of register B is copied into register A using a data point connector.

The configuration software is able to check for such loops when they are caused entirely by internal objects. In such a case, the project cannot be downloaded into the device and a warning message appears, showing the objects which cause the infinite update loop.

However, the configuration software cannot check loops which are closed via the network, because it does not have enough information to do this. For example, if a data point connector is used to connect a switch input SI to a switch output SO, this in itself does not constitute a loop at all. But when the update of SO on the network is sent to a lamp actuator and the lamp actuators feedback output is connected to the switch input SI, the result may be an infinite update loop between the L-Vis device and the lamp actuator, depending on how the actuator behaves. Once the L-Vis sends out an update on SO, it will be received by the lamp actuator. This may cause the actuator to send out an update on the feedback output, which will be received by L-Vis on the input SI, which in turn will be copied by the data point connector to the output SO and so on. The result can have adverse effects on the network performance and the performance of the devices in the loop, so special care should be taken to avoid such setups.

User defined Fonts

Every device has a set of three basic fonts which cover the ISO8859-1 (Latin-1) code set in three different sizes. To extend the available choices, the configuration software and the device support user loadable fonts in most common formats, including TrueType, Type1, BDF, PCF and others.

The L-Vis configuration software is shipped with a set of selected freeware PCF fonts to cover Western (ISO8859), CJK (Chinese, Japanese, and Korean) and also Unicode (UCS16) character sets. These should cover your immediate needs for a large number of languages.

The provided PCF fonts are fixed size fonts, meaning that each of them is designed and optimized to a specific resolution. Most fonts are therefore available in a number of variants, starting at very small sizes, up to about 24 pixel resolution. For larger sizes or other designs you may load vector fonts as well, in which case you will have to specify a font size in points (1/72 inch) and the configuration software will render the font in the desired size for you. If the loaded font file is a font catalog (for example *.ttc), you may also select the desired face which should be rendered.

NOTE: It is recommended to use fixed size fonts, like the provided PCF fonts, for small sizes (up to 24 pixel resolution) and load vector fonts for large sizes. Since the L-Vis device has a limited LCD resolution and cannot support anti-aliased fonts due to hardware limitations, a small rendition of a vector font will not look as clean as a fixed size font which was designed and optimized to a specific target resolution.

Font File Location

When a project contains a user defined font, it is necessary to have access to the original font file when working with the project. This is guaranteed as long as only the pre-installed fonts are used, since they are located in a known place on every installation of the configuration software. However, if fonts from an external source are used, they too must be available whenever the project is loaded and modified and the user has to make sure to deliver the font file together with the L-Vis project file, if the project is to be edited on a different PC, where the font may not be available at the same location.

To locate the original font file, the configuration software will automatically try the following locations in the given order until a suitable font is found:

- The full path from where the font was built the last time.
- The directory containing the project file.
- The fonts directory of the configuration software installation.

If the font cannot be located in any of these places, the user is asked to provide an alternative font file.

Based on the above search order, the easiest way to make sure that a project can be used on any PC is to store all custom fonts which are used in the project in the same place where the project file itself is located. For example create a folder to store the project file together with all custom font files in one place. Now the entire folder may be copied to any other PC and the required font files will always be found automatically.

Font Recoding

The L-Vis configuration software as well as the L-Vis device itself are Unicode enabled. All text entered in the configuration software and displayed on the device is encoded using the 16-bit international Unicode standard UCS-16. PCF and BFD fonts may use other encodings, such as ISO8859, JISX0212, Big5, IBM, or Microsoft codepages (for example MS-CP1250). If such a font is loaded, it is automatically recoded to UCS-16 before it is used, since the L-Vis device does not recognize encodings other than UCS-16. The font recoding is done using the coding tables found in the directory *Encodings,* located in the program directory. New encodings may be added to make them available for the import of fonts.

NOTE: Fonts in other formats than BDF or PCF should contain an ISO8859-1 or ISO10646 (Unicode) codepage, or Adobe Type-1 glyph names in order to facilitate recoding to UCS-16. While there are practically no vector fonts which do not provide any of this information, it may be an issue when loading old Windows fonts for other than western languages. Such fonts may be converted to BDF format in order to allow recoding using the installed encoding tables.

PCF File Format

The PCF Font file format is a free, open file format, designed to store bitmap fonts. The specification of the file format can be found at http://pfaedit.sourceforge.net/pcf-format.html.

NOTE: Since PCF is a free format, there is information available on the internet about font conversion utilities to convert existing fonts from other formats (e.g. True Type fonts) to PCF format. These fonts can then be used on the L-Vis device. Tools which are freely available to convert from Windows TTF fonts to

PCF format include `otf2bdf` to convert the TTF or OTF font to BDF format of a given pixel size and `bdftopcf` to convert the BDF file into a PCF font.

Using Color Bitmaps

Current L-Vis devices use a 256 color display with a standard VGA palette. If a true color image is loaded, like for example a JPG, 32-bit BMP or similar, the configuration software will automatically adjust the image to fit the VGA palette, using a Floyd-Steinberg dithering algorithm. This algorithm, which is based on error dispersion, is applied in conjunction with an alternating raster scan technique to provide the best possible result, so it is not necessary to run your JPG through the same color reduction algorithm using a separate graphic editor. You will not be able to see any difference.

However, due to the limited resolution, dithering will be noticeable when viewing the images from a close distance, which will be OK for photo-realistic color graphics, but might be unwanted for line-art graphics, which contain large areas of uniform color. In such areas, dithering to the exact color would not look as good as just picking one color from the VGA palette which is closest to the intended color.

If this is required, it is best to design the graphics already using the VGA palette and saving them in 256-color indexed format, like for example 8-bit BMP or GIF. It is important to make sure that the palette used by the graphic tool is in fact the VGA palette, because when you later load the indexed color image into your project, the software will make no further modifications to the image, to guarantee a 1:1 match of what you designed and to avoid double-dithered images resulting in poor quality (see note below). If color number 0 in your image does not refer to black, or color number 255 does not refer to white, as the VGA palette does, the image will look different. However, you will see this immediately in the LCD preview window.

NOTE: If you import an already existing bitmap and it appears in wrong colors, the bitmap is already in indexed color format but uses a different (non-VGA) color table, most likely optimized to the contents of the picture. As explained above, the configuration software does not modify the pixel data in such a case. This is because images like this are most likely already dithered to fit the 256 colors in which they were saved. To convert such a picture to VGA colors, the already dithered image would have to be run through the dithering algorithm again, which is likely to result in very poor quality images. In such a case, it is better to get the original versions of the pictures (true color or vector graphics) and create suitable VGA graphics from this source. If this data is not available, the existing pictures may also be converted to true color images before use, which will then trigger dithering to the VGA color palette.

The following image file types are supported:

- Bitmaps (*.bmp)
- Icons (*.ico)
- Joint Photographic Experts Group / JPEG (*.jpg)
- Tagged Image File Format / TIFF (*.tif)
- Portable Network Graphics /PNG (*.png)
- Graphics Interchange Format / GIF (*.gif)

The file open dialog automatically shows all supported graphic files it finds in the directory. Unsupported files are hidden. True color or high color images will automatically be dithered and converted to the fixed VGA color palette used by

L-Vis, as explained above, 8-bit indexed color files (like GIF) will be loaded as-is without any changes.

Examples

This section shows how to use the different controls in a sample project. The project can be found in the *Projects* directory of the L-Vis configuration software install directory (Users_Manual_Color.lcp).

Example 1: Working with Structured Network Variables

This example describes how to work with structured network variables like SNVT_switch. It explains how structured input and output network variables can be used with different controls.

This example assumes that a dynamic input variable of type SNVT_switch (nviSwitch) and a dynamic output network variable of type SNVT_switch (nvoSwitch) is already present on the node. We will use the output variable to update the value on the network and will use the input variable as a feedback value from the network. The example explains how to use this setup with different controls.

Text control

With this example, we will be able to show the state of a SNVT_switch (e.g. a lamp) and control the state from the L-Vis device, using a text control. Text controls are typically used to display a complex text or to allow input where the user can select between several different input strings (e.g. HIGH-MID-LOW).

To use the SNVT_switch variables with a text control, perform the following steps. The control only changes the state value of the output network variable and fixes the value element of the network variable to 100%.

1. Add a text control to the page
2. In the common properties tab, add a label to the format string in the **Text** field. (e.g. Switch: %s).
3. Add data points to the control. To do this, select *Add Data Point* from the context menu of the control. Add an input data point for nviSwitch.state and output data points for nvoSwitch.state and nvoSwitch.value. A default mapping between the state input values and the displayed text is automatically added to the control.
4. For the input data point (nviSwitch.state), set the **System Startup** flag on the **Data Point** configuration tab.

5. For the nvoSwitch.value network variable, go to the **Data Point** configuration tab, configure the **Default Value** to 100 and set the **Constant Value** flag. Set the **NV Update Flags** value to **Focus Loss**.
6. For the nvoSwitch.state network variable, set the **NV Update Flags** value to **Focus Loss**.
7. The configuration now looks similar to Figure 21. The project can now be loaded into the L-Vis device.
8. To change the state of the output network variable, select the text control by operating the jog dial until a frame is displayed around the text control. Select the control with a short click.. Now the frame starts flashing which signals that the control is in input mode. Turn the jog dial to change the state. Pressing the jog dial again deselects the text control.

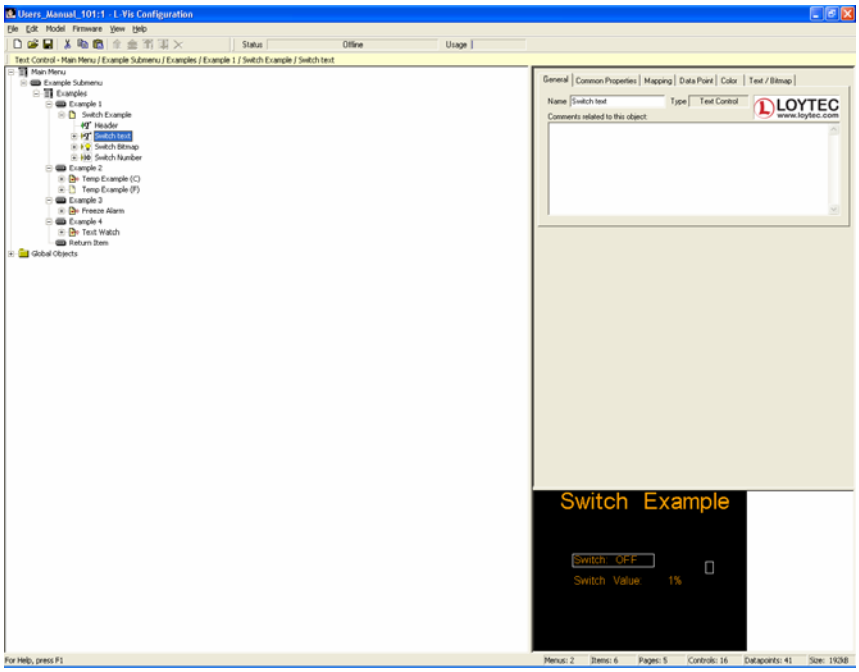


Figure 21: SNVT_switch with a text control

Bitmap Control

Bitmap controls are typically used for information which has only a few states (like heating on/off, light on /off).

This example shows how to use a SNVT_switch together with a bitmap control. It also fixes the value part of the SNVT_switch network variable to 100 and toggles only the state part.

1. Add a bitmap control to the page
2. Add data points to the control. To do this, select *Add Data Point* from the context menu of the control. Add a input data point for nviSwitch.state and output data points for nvoSwitch.state and nvoSwitch.value. A default mapping between the state input values and the displayed text is automatically added to the control.
3. For the input data point (nviSwitch.state), set the **System Startup** flag on the **Data Point** configuration tab.
4. For the nvoSwitch.value network variable, go to the **Data Point** configuration tab, configure the **Default Value** to 100 and set the

Constant Value flag. Set the **NV Update Flags** value to **Focus Loss**.

5. For the nvoSwitch.state network variable, set the **NV Update Flags** value to **Focus Loss**.
6. Select the mapping item in the tree view and go to the **Mapping** tab. In the value list, select OFF. Click on **Select Bitmap** and choose a bitmap which should be displayed when the switch is OFF. After this, select ON in the value list and select the bitmap for the ON state.
7. The configuration now looks similar to Figure 22. The project can now be loaded into the L-Vis device.

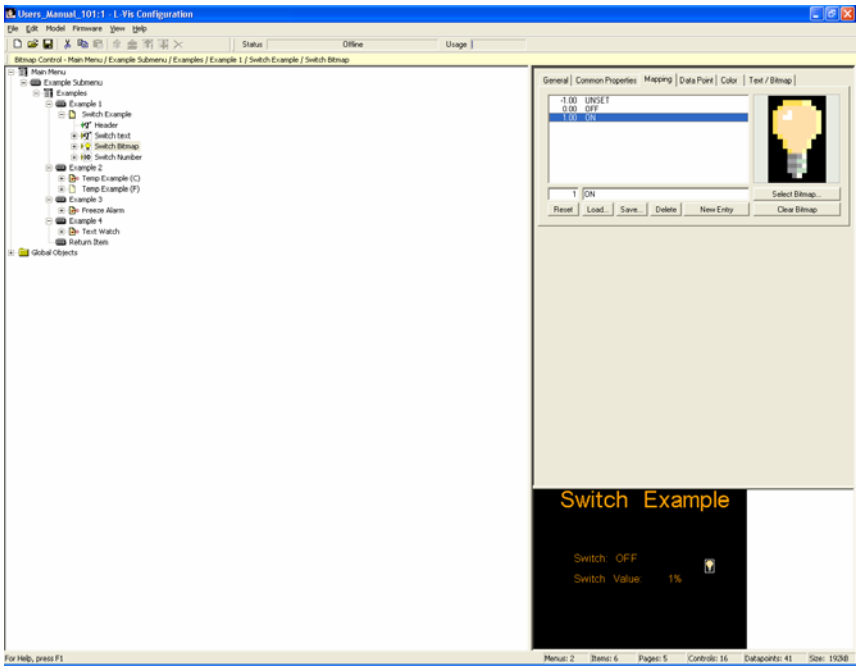


Figure 22: SNVT_switch on a bitmap control

Numeric Control

A numeric control is used whenever a data point needs a continuous numerical output or input, like a percentage value or a temperature value.

This example shows how to use a SNVT_switch together with a numeric control. The state element of the SNVT_switch network variable is fixed to 1, whereas the value part can be set between 0 and 100.

1. Add a numeric control to the page
2. Add data points to the control. To do this, select *Add Data Point* from the context menu of the control. Add an input data point for nviSwitch.value and output data points for nvoSwitch.state and nvoSwitch.value. A default mapping between the state input values and the displayed text is automatically added to the control.
3. For the input data point (nviSwitch.value), set the **System Startup** flag on the **Data Point** configuration tab.
4. For the nvoSwitch.state data point, go to the **Data Point** configuration tab, configure the **Default Value** to 1 and set the **Constant Value** flag. Set the **NV Update Flags** value to **Focus Loss**.

5. For the nvoSwitch.value data point, set the **NV Update Flags** value to **Focus Loss**, adjust the **Value Range** to values between 0 and 100 and set the **Acceleration** to 2.

6. The configuration now looks similar to Figure 23. The project can now be loaded into the L-Vis device.

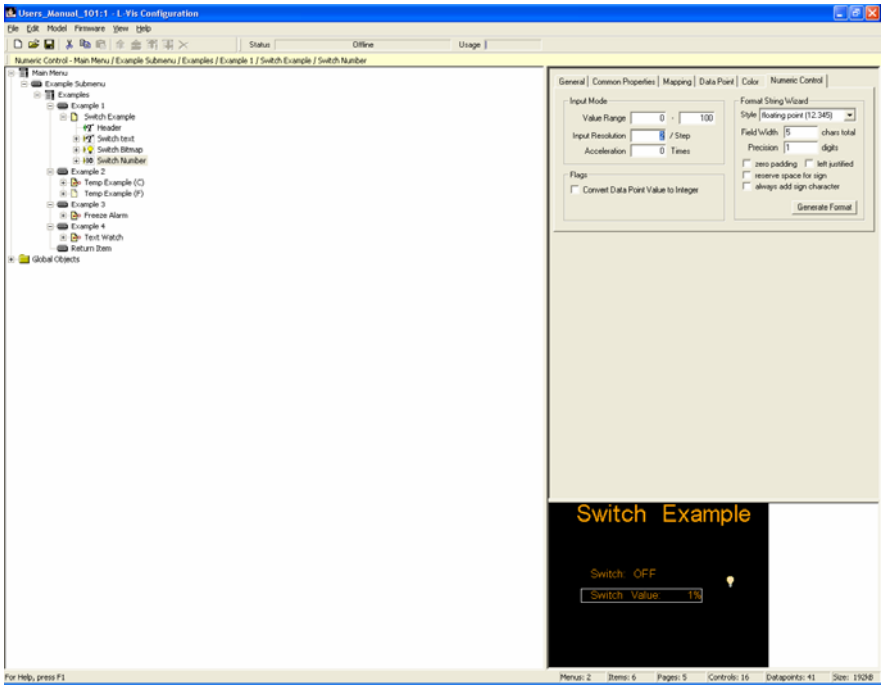


Figure 23: SNVT_switch on a numeric control

Example 2: Using Data Point conversion and Hiding of Pages

This example will use an input value of type SNVT_temp_p. It will provide the temperature value on a bar graph and a numeric control. The data will be shown in two versions, one for degree Celsius and one for Fahrenheit. The two display versions will be placed on different pages. The example will show how to use the hide flag in order to load the project into the L-Vis device with the localized configuration. The example walk-through description assumes that a dynamic network variable nviTemp of type SNVT_temp_p is already created on the L-Vis device.

1. Create a menu item and add a page to the menu item. Name the page, e.g. to Temp Example (C). Add a text control to the page and enter a header text for the page (e.g. Temperature).

2. On the page, create a bar control (select *Add Bar* from the context menu of the preview frame). Name the bar graph (e.g. Temp Bar) in the **General** tab.

3. On the **Bar Graph** tab, enter the value range for the bar graph (e.g. -20 to +40) and set the flag for **Thermometer Style**.

4. Select *Add Data Point* from the context menu of the bar graph. From the data point template list, select the nviTemp input data point.

5. Make sure that the **Value Translation Setting** on the **Data Point** tab is set to OFF.

6. Select the page in the tree view. In the context menu of the page, choose *Copy*. Go to the menu item (e.g. Example 2), open the context menu and choose *Paste*. A copy of the page is inserted n the menu.
7. Change the name and text of the page to Temp Example (F).
8. Select the input data point which is connected to the bar graph in the newly created page. Set the Value Translation Setting to °C-->°F.
9. Depending on whether the Temperature should be shown in Fahrenheit or Celsius, set the **Invisible Page** flag on the **Menu/Page** tab of the corresponding page.
10. Load the project into the L-Vis device. Only the page, which does not have the Invisible Page flag set, shows up in the L-Vis device (see Figure 24).

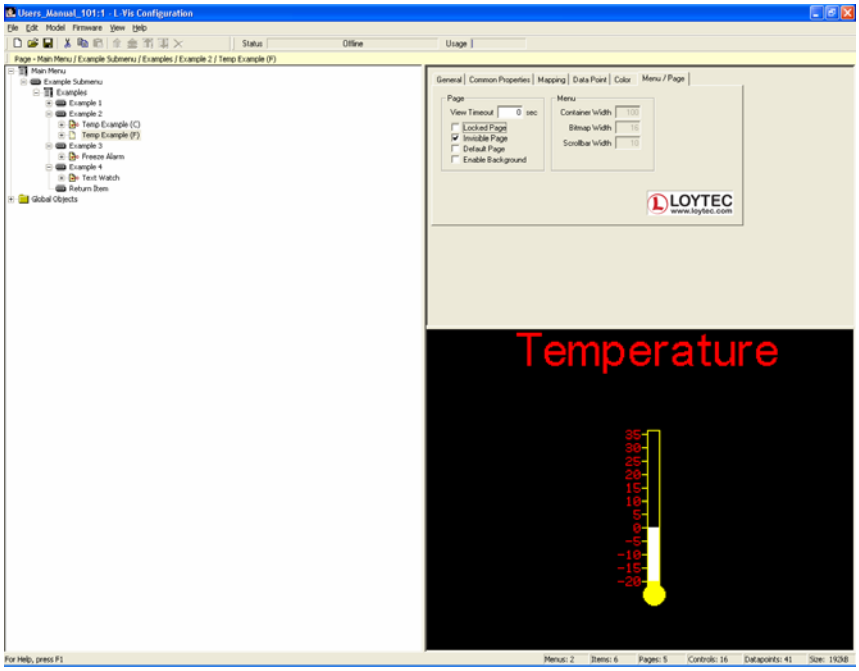


Figure 24: Hiding pages

Example 3: Freeze warning, Alarms and Registers

This example shows how to create a translation table which converts a numeric value to a text value and to generate an alarm output on special occasions. It also shows how to use registers to exchange data between internal objects. The example takes an nvoTemp input data point and checks if it is below 0°C (freeze warning) or not. It controls an output text and an alarm output register of type SNVT_alarm_2.

1. Generate a new menu item (Example 3) and a page for this menu item and name the menu item and the page. Generate a header for the page (Freeze Warning).
2. Add a new text control to the page. Set a label for the text control (e.g. Temperature State: %s) in the text field of the **Common Properties** tab.
3. Add the nviTemp data point to the text control. Select the **Mapping** tab on the data point. Select New, enter 0 for the value

and FREEZE for the text. Add two more mapping values (0,1, ATTENTION and 3, NORMAL) to the mapping table. This will cause that for input values up to 0,1°C, the FREEZE text will be shown. Values between 0,1°C and 2,99°C will show ATTENTION, where as values starting with 3°C will show NORMAL in the text control. *Figure 25* shows a screenshot of the mapping table.

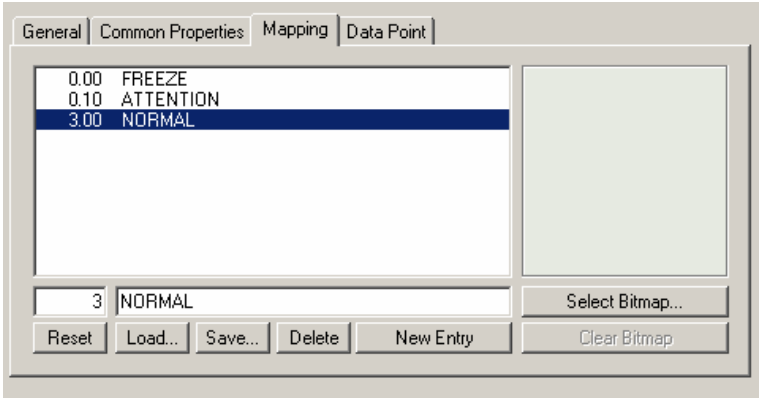


Figure 25: Mapping table

4. In the tree view, open the context menu of **Global Objects** and add an alarm generator. Label the alarm generator with 'Freeze Alarm".

5. On the context menu of the alarm generator, select *Add Data Point*. Since we have no output network variable of type SNVT_alarm_2, we will generate a register, which stores the value of the alarm generator. To create a new register, click on the *New* button, and edit the field on the bottom of the dialog window. For the **Name**, enter 'rwFreezeAlarm', for **Type** select 'Reg.Write'. Change the **Name** in the Register Properties field to 'FreezeAlarm' and set the **Type** to alarm_2(164). For Element keep the value '*'. Select the new element in the list and click on OK.

6. Select *Add Data Point* again on the context menu of the alarm generator and add the nviTemp data point to the alarm generator.

7. In the **Alarm Generator** tab (*Figure 26*) of the alarm generator, set the alarm conditions for the alarm. We will trigger an alarm when the temperature falls below 3°C. For the **Data Point Value Range**, set the minimum value to 3. For the **Alarm Condition**, select *Below Min*. In the **Action** field select *Set and Clear Alarm*. For **Alarm Set Type** select AL_ALM_CONDITION. For **Alarm Clear Type** select AL_NO_CONDITION. In the **Description** field, enter 'Freeze Alarm'. The different alarm types and their meaning can be found in the LONMARK® description of the SNVT_alarm_2 network variable type.

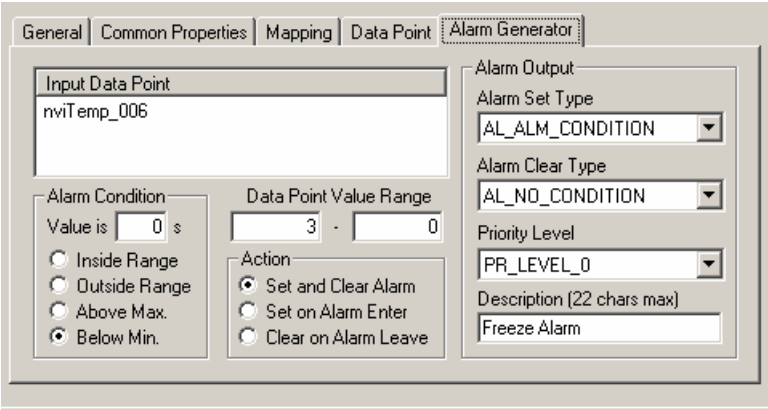


Figure 26: Alarm Generator configuration tab

8. To display the alarm output we will draw a bitmap which shows an ice symbol in alarm state. To do this add a bitmap control to the page. Enter a label for the bitmap in the **Text** box of the **Common Properties** tab.

9. Select Add Data Point on the context menu of the bitmap control. Add a Reg.Read data point as described above and use the same name (FreezeAlarm) for the **Name** in the **Register Properties** field. Set the **Type** to alarm_2(164) and select alarm_type for the **Element**.

10. On the **Mapping** tab of the data point, select the AL_ALM_CONDITION. Click on Select Bitmap and choose a bitmap which is displayed when the alarm condition is met.

11. Load the project into the L-Vis device.

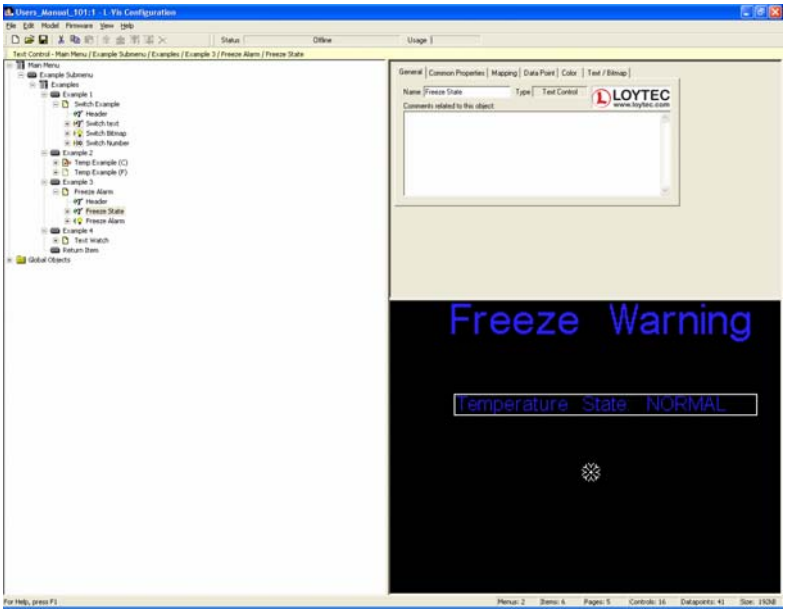


Figure 27: Freeze alarm with text and bitmap controls

Example 4: Using text mapping and Date Control

This example describes how to integrate a date control into a project. The date control will display an analog clock. It will get the time value from the internal real time clock. In addition, three text fields will be created which display the actual time in a textual format. The time value for this text will be received from a turnaround binding of the real time keeper object.

1. Create a new menu item and assigned a page to this menu item. On the page, add a text control for the header text, name it (e.g. 'Header' and enter a text in the **Text** field of the **Common Properties** tab (e.g. 'Text Watch')
2. In the context menu of the new page, select **Add Date**.
3. In the context menu of the date control, select **Add Data Point**. In the dialog window, select the System Time parameter and click on OK.
4. On the Date/Time Control tab, select *Graphic* for the **Style** and choose a Graphic Style.
5. For the text display, we need a turnaround bound dynamic network variable which allows to access hours, minutes and seconds separately. Create a dynamic network variable of type SNVT_time_stamp and bind the nvoDateTime variable of the L-Vis device to this input variable (see Figure 28).

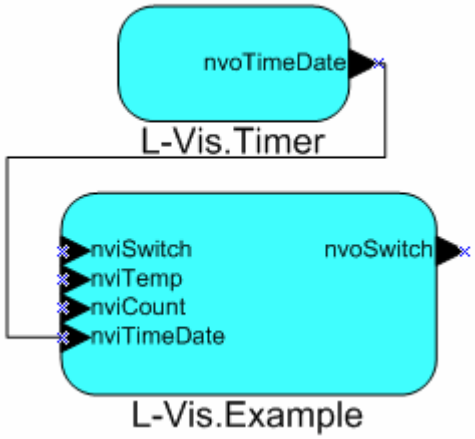


Figure 28: Turnaround binding for the time network variables

6. Add a text control to the page and name it 'Hour". Use the context menu of the text control to add a data point. Select the new time stamp input network variable and select **hour** in the **Element**.
7. Create two more text controls, one for the minutes and one for the seconds. Assign the minutes and seconds Elements from the time stamp input data point to the controls.
8. On the mapping tab of one of the text controls, create new entries for the numbers from 0 to 59 and add the text for the numbers (e.g. one for 1, two for 2,…). Save this mapping table to a file (button **Save**).
9. Go to the mapping tabs of the other text controls and load the stored mapping table.
1. Load the project to the L-Vis device. To show the correct text the update interval of the timer object has to be set to 1 second.

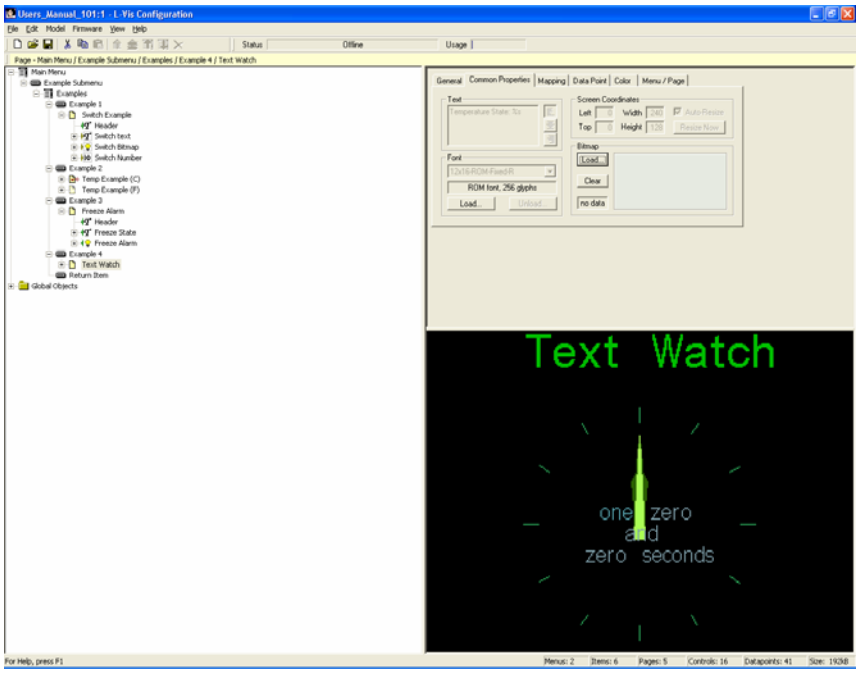


Figure 29: Text Watch project

Solutions

This section describes solutions for some standard applications. The solution projects can be found in the *Projects* directory of the L-Vis configuration software install directory.

Implementing Menus

By default, the user can navigate in a project using the main menu, submenus and push and drag operations. With the help of bitmap controls, text controls and action objects it is also possible to implement alternative ways to navigate inside an L-Vis project. The project Menu_example1.lcp shows different solutions.

Tab Menus

To switch between multiple pages, a tab menu can be implemented using bitmap controls, text controls and action objects (see Figure 30).

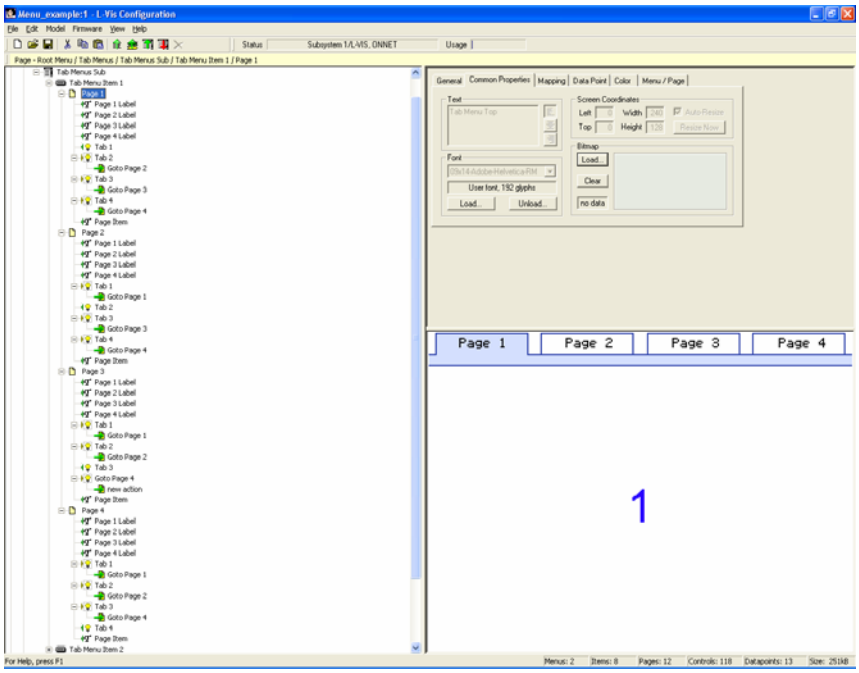


Figure 30: Page navigation using Tabs

Each page contains four bitmap controls. There are two types of bitmaps: one for the active page (Figure 31) and one for the inactive page (Figure 32).

Figure 31: Active page bitmap

Figure 32: Inactive page bitmap

The bitmaps are aligned to form a row of tabs. On each tab, a text control is placed with identifies the page and the page links (in the example it is called Page 1, Page 2,…). To each of the inactive page bitmap controls an action object is assigned. The action to execute is to change to the respective page. This setup has to be copied for each page, but he location of the active page bitmap changes according to the page on which the controls are placed.

The same mechanism can be used to build tabs on the bottom, which is also shown in the menu project (Tab Menu Bottom, Figure 33).

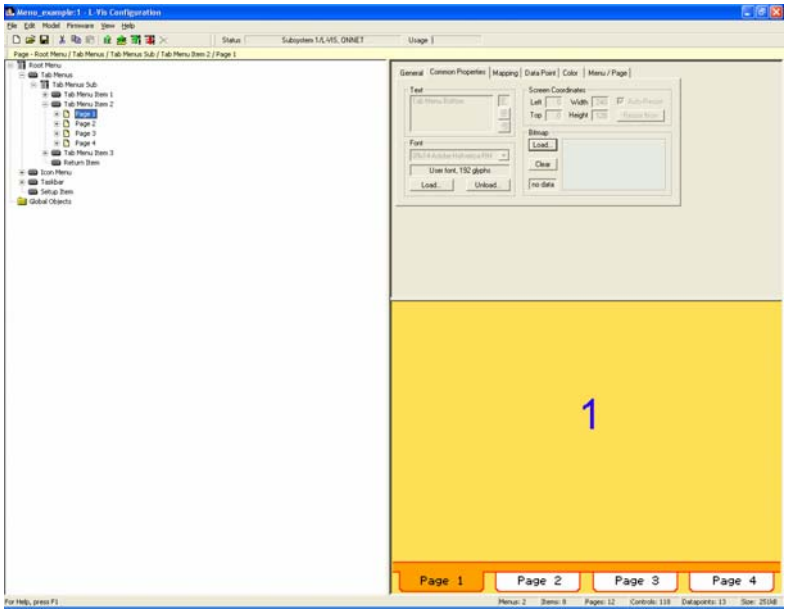


Figure 33: Bottom tab menu solution

Another tab solution in the project shows how to implement flat tabs, but using only line bitmaps. In that solution, the action objects are assigned to the text controls. The leftmost button in that case opens the main menu (Figure 34).

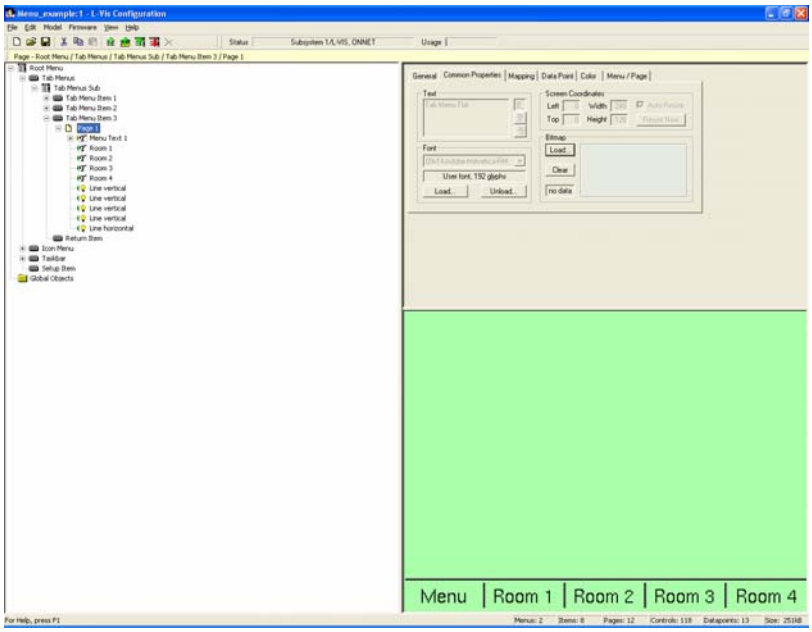


Figure 34: Flat tabs and menu button

Icon Menus

Another common implementation to navigate in menu trees is to use icon menus as shown in the icon menu example (see Figure 35).

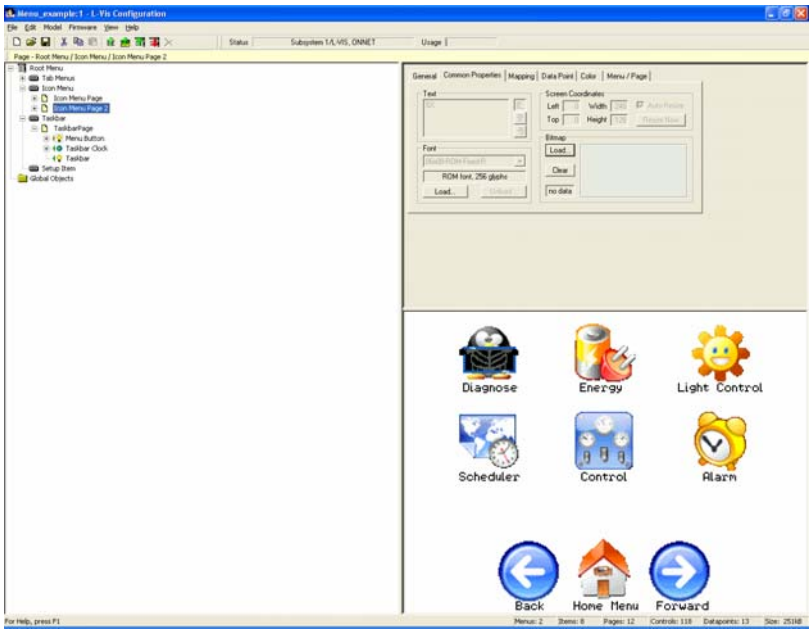


Figure 35: Icon menu

On an empty page as set of bitmap controls is placed. Each bitmap represents a page or a submenu. In the example, a text control is placed below each bitmap icon. An action object, which executes a switch to a linked page, is assigned to each bitmap control.

On the bottom of the example page, three additional bitmaps are placed, which have action assigned to switch pages back and forth and to open the system menu.

Using the icon menus, it is also possible to implement the whole navigation without the default menu. In that case, the main menu page should have the checked the default page checkbox in the Menu/Page tab.

Taskbar Menu

To simulate a PC environment, a system with a setup with a task bar can be created (Figure 36).

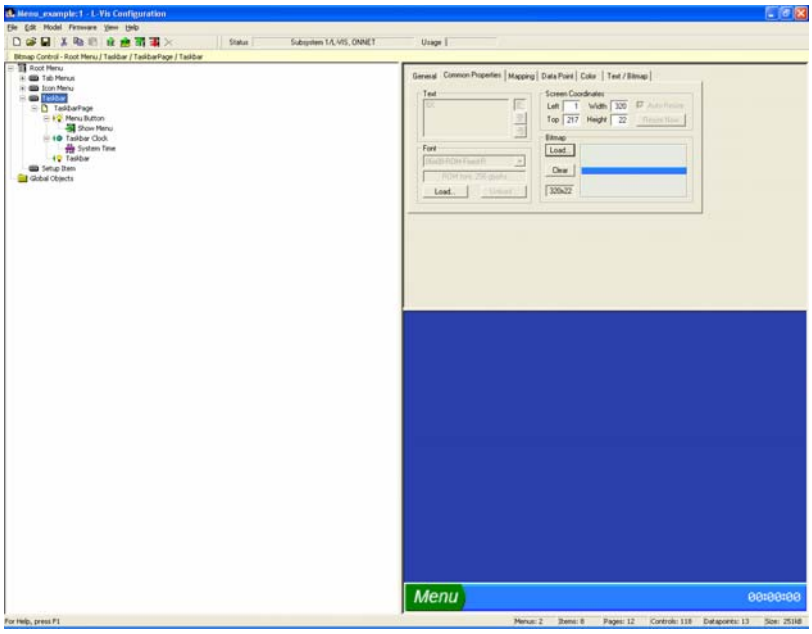


Figure 36: Taskbar menu

The taskbar is formed by a bitmap control. The bitmap for the menu button is placed on top of the taskbar bitmap. An action object is assigned to the menu button bitmap. This action object opens the main menu. In the example a date control which displays the current time is placed on the task bar.

It would also be possible to add further icons to the taskbar, which open other pages. Also icons which are only displayed when an alarm occurs, could be added.

Bitmap Menu

The bitmap menu shows a navigation using full screen bitmaps with touch sensitive zones. On the main page, the Floor 1 can be selected, and on the floor page the upper left room. The back button brings the user one level back.

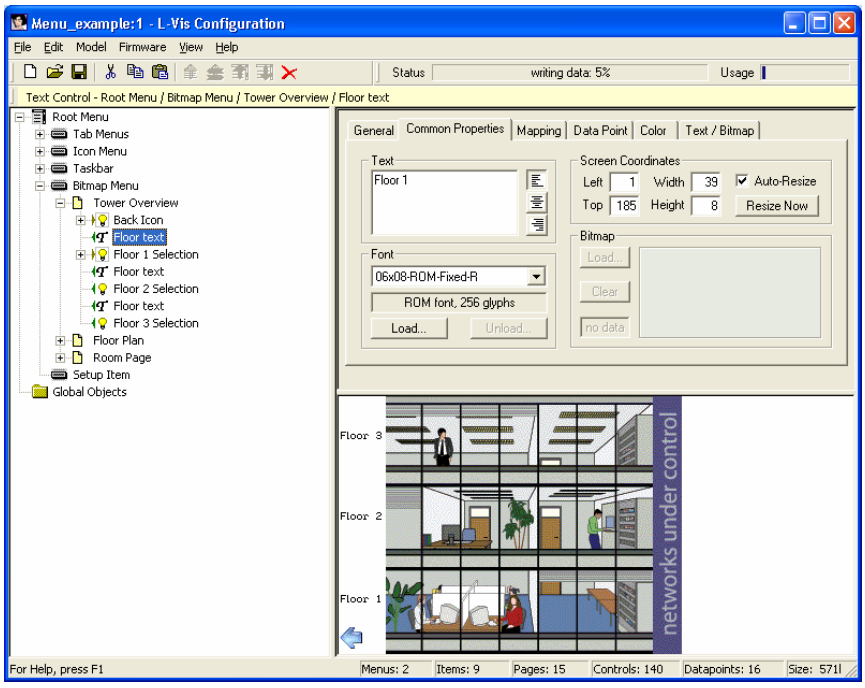


Figure 37: Bitmap menu configuration

Light Control

The project “Solution_examples_manual.lcp” contains a “Switch Demo” page.

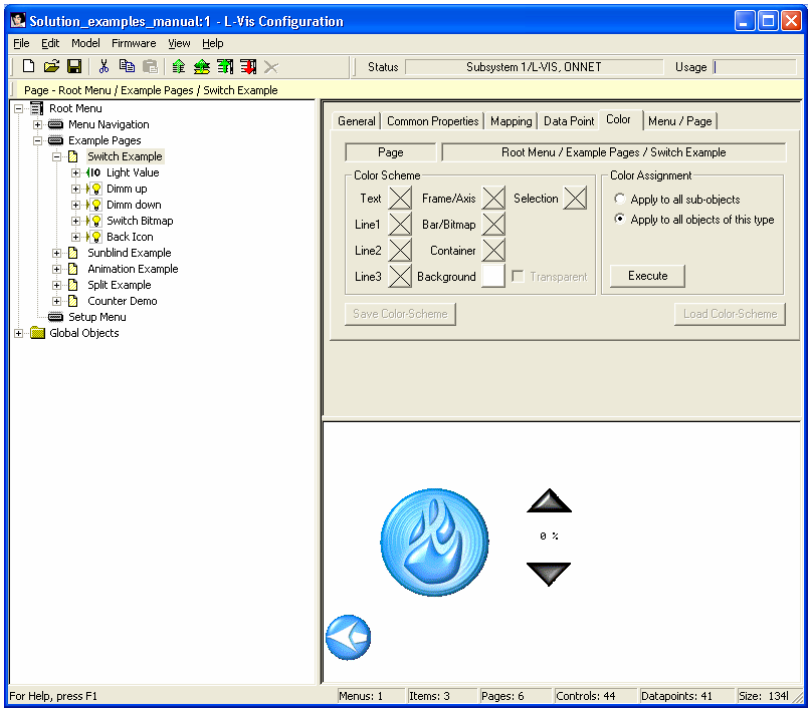


Figure 38: Switch demo page

The example uses a bitmap control in push button mode to switch the state of a SNVT_switch on or off. Two arrows allow to increase and decrease the value part of the SNVT_switch variable. To increase and decrease the values, action controls are assigned to the bitmap controls. The increase and decrease operations are executed by two mathematic objects. The operation results are exchanged between the mathematic object and the bitmap controls using a register.

Animated Bitmaps

The project “Solution_examples_manual.lcp” contains a “Animation Demo” page.

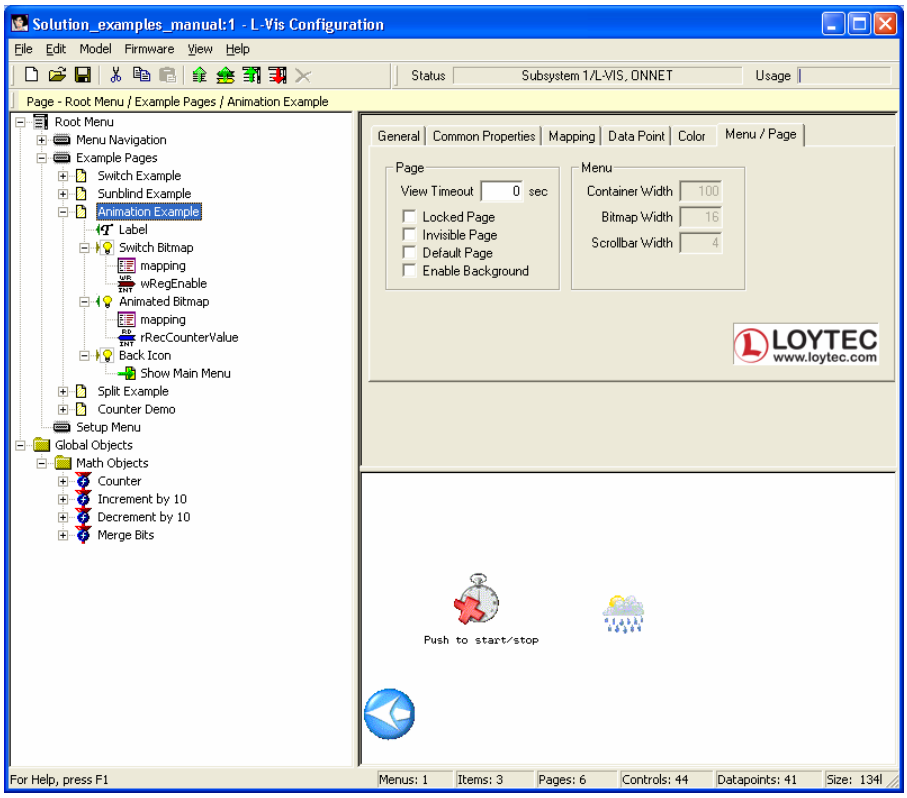


Figure 39: Animation Demo configuration

The animation demo shows how to generate animated bitmap controls.

A bitmap control in push button mode starts and stops the animation. The animated bitmap is built of a bitmap control together with a mapping table. The input for the animated bitmap is generated by a mathematic object. The mathematic object is feed by the system time and performs a modulo operation on this input. An additional enable register parameter allows to enable or disable this modulo operation.

Sunblind Demo

The project “Solution_examples_manual.lcp” contains a “Sunblind Demo” page.

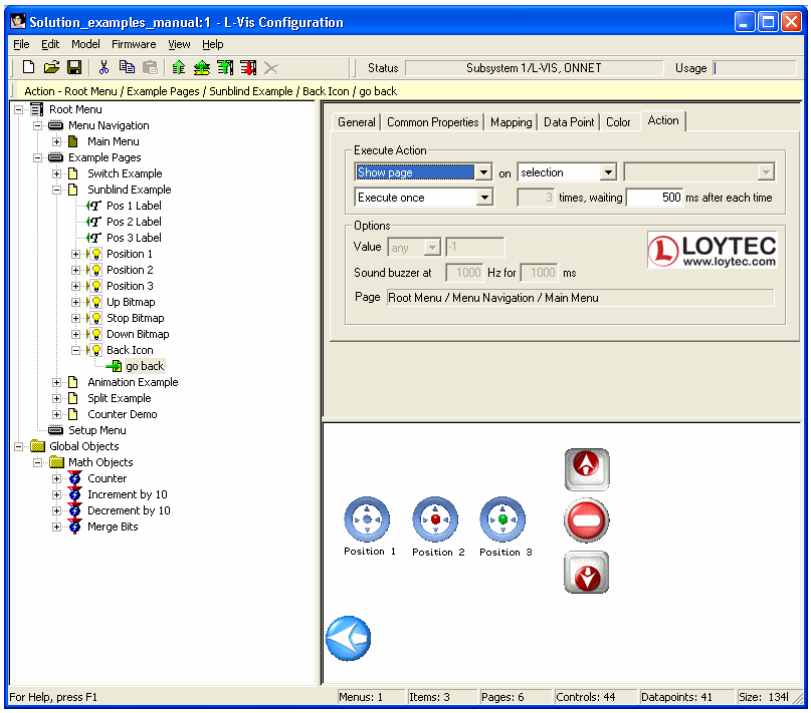


Figure 40: Sunblind demo configuration

Like in the switch example, the sunblind demo uses bitmap controls together with action objects to move a sunblind to special positions or move the sunblind up, down or stop the sunblind.

Split Demo

The project “Solution_examples_manual.lcp” contains a “Split Demo” page.

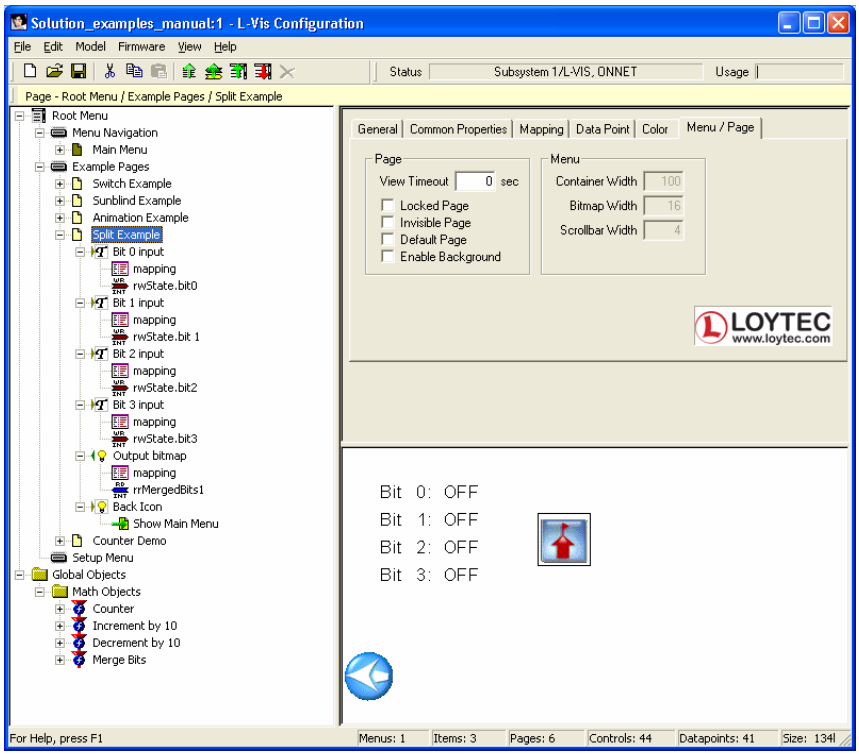


Figure 41: Split example configuration

The split demo shows how to merge the input of a SNVT_state variable into a single bitmap control. In some projects it is required to evaluate the input of a SNVT_state variable, where only one bit is set, and display the result in a single bitmap or text control. The example uses the single bits of the SNVT_state variable to feed a mathematic object. The mathematic object encodes the bit to a single numeric value and passes the result to a register. The register feeds the mapping table of a bitmap control, which displays different bitmaps according to the register contents.

Counter Demo

The project “Solution_examples_manual.lcp” contains a “Counter Demo” page.

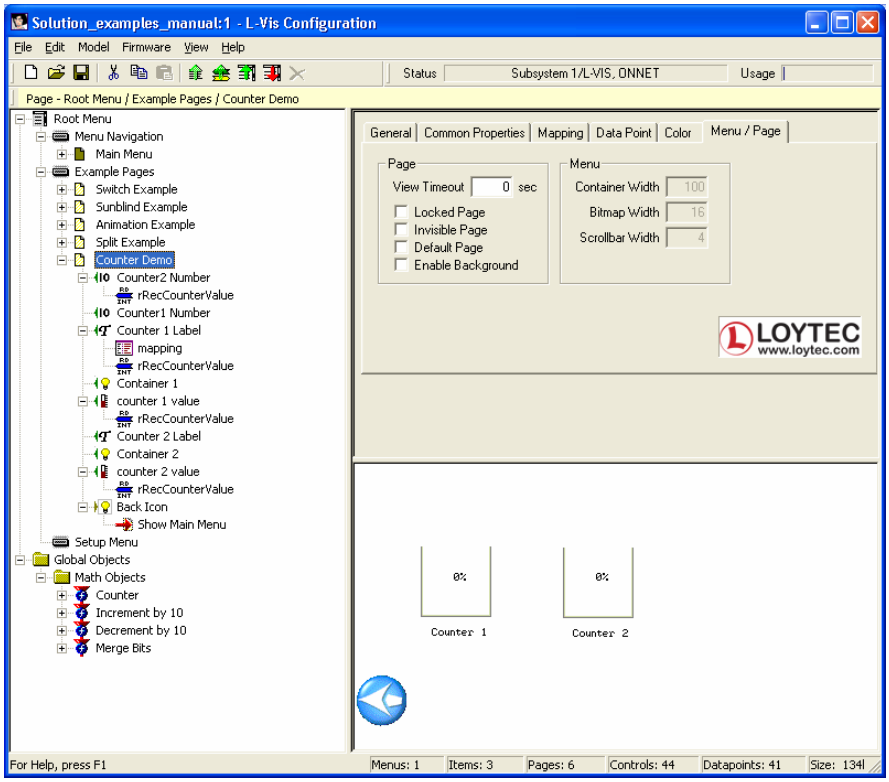


Figure 42: Counter demo configuration

The counter demo shows how to use a bar graph control to simulate the fill level of a container. An empty container is formed by a bitmap control. On top of the bitmap control, a bar graph control is placed. All relevant colors except the Bar/Bitmap color are set transparent, so that the bar graph forms the filling of the container.

Appendix A: Format strings

Format string description

The format string used in text controls and numeric controls is equivalent to the format strings used by the ANSI-C printf function. L-Vis will always use the given format string to format exactly **one argument**, which will be a string, an integer, or a double precision floating point number, depending on the type of control and its configuration. Therefore, there should always be exactly **one conversion specifier** in an L-Vis format string and its type needs to match the argument provided by the control. For example, it will not work to use a %d specifier for a text control or a %s specifier for a numeric control.

The format string is composed of zero or more directives: ordinary characters (not **%**), which are copied unchanged to the output stream; and conversion specifications, each of which results in fetching zero or more subsequent arguments. Each conversion specification is introduced by the character **%**, and ends with a *conversion specifier*. In between there may be (in this order) zero or more *flags*, an optional minimum *field width*, an optional *precision* and an optional *length modifier*. The arguments must correspond properly (after type promotion) with the conversion specifier. By default, the arguments are used in the order given, where each '*' and each conversion specifier asks for the next argument (and it is an error if insufficiently many arguments are given). One can also specify explicitly which argument is taken, at each place where an argument is required, by writing '%m$' instead of '%' and '*m$' instead of '*', where the decimal integer m denotes the position in the argument list of the desired argument, indexed starting from 1. Thus, "%*d" and "%2$*1$d" are equivalent. The second style allows repeated references to the same argument. The C99 standard does not include the style using '$', which comes from the Single Unix Specification. If the style using '$' is used, it must be used throughout for all conversions taking an argument and all width and precision arguments, but it may be mixed with '%%' formats which do not consume an argument. There may be no gaps in the numbers of arguments specified using '$'; for example, if arguments 1 and 3 are specified, argument 2 must also be specified somewhere in the format string. For some numeric conversions a radix character ('decimal point') or thousands' grouping character is used. The actual character used depends on the LC_NUMERIC part of the locale. The POSIX locale uses '.' As radix character, and does not have a grouping character.

The flag characters

The character % is followed by zero or more of the following flags:

The value should be converted to an ''alternate form''. For **o** conversions, the first character of the output string is made zero (by prefixing a 0 if it was not zero already). For **x** and **X** conversions, a nonzero result has the string '0x' (or '0X' for **X** conversions) prepended to it. For **a**, **A**, **e**, **E**, **f**,**F**, **g**, and **G** conversions, the result will always contain a decimal point, even if no digits follow it (normally, a decimal point appears in the results of those conversions only if a digit follows). For **g** and **G** conversions, trailing zeros are not removed from the result as they would otherwise be. For other conversions, the result is undefined.

0 The value should be zero padded. For **d**, **i**, **o**, **u**, **x**, **X**, **a**, **A**, **e**, **E**, **f**, **F**, **g**, and **G** conversions, the converted value is padded on the left with zeros rather than blanks. If the **0** and − flags both appear, the **0** flag is ignored. If a precision is given with a numeric conversion (**d**, **i**, **o**, **u**, **x**, and **X**), the **0** flag is ignored. For other conversions, the behavior is undefined.

− The converted value is to be left adjusted on the field boundary. (The default is right justification.) Except for **n** conversions, the converted value is padded on the right with blanks, rather than on the left with blanks or zeros. A − overrides a **0** if both are given.

' ' (a space) A blank should be left before a positive number (or empty string) produced by a signed conversion.

+ A sign (+ or -) always be placed before a number produced by a signed conversion. By default a sign is used only for negative numbers. A **+** overrides a space if both are used.

The field width

An optional decimal digit string (with nonzero first digit) specifying a minimum field width. If the converted value has fewer characters than the field width, it will be padded with spaces on the left (or right, if the left-adjustment flag has been given). Instead of a decimal digit string one may write '*' or '*m$' (for some decimal integer m) to specify that the field width is given in the next argument, or in the m-th argument, respectively, which must be of type *int*. A negative field width is taken as a '-' flag followed by a positive field width. In no case does a non-existent or small field width cause truncation of a field; if the result of a conversion is wider than the field width, the field is expanded to contain the conversion result.

The precision

An optional precision, in the form of a period ('.') followed by an optional decimal digit string. Instead of a decimal digit string one may write '*' or '*m$' (for some decimal integer m) to specify that the precision is given in the next argument, or in the m-th argument, respectively, which must be of type *int*. If the precision is given as just '.', or the precision is negative, the precision is taken to be zero. This gives the minimum number of digits to appear for **d**, **i**, **o**, **u**, **x**, and **X** conversions, the number of digits to appear after the radix character for **a**, **A**, **e**, **E**, **f**, and **F** conversions, the maximum number of significant digits for **g** and **G** conversions, or the maximum number of characters to be printed from a string for **s** and **S** conversions.

The length modifier

Here, 'integer conversion' stands for **d**, **i**, **o**, **u**, **x**, or **X** conversion.

hh A following integer conversion corresponds to a *signed char* or *unsigned char* argument, or a following

n conversion corresponds to a pointer to a *signed char* argument.

h A following integer conversion corresponds to a *short int* or *unsigned short int* argument, or a following

n conversion corresponds to a pointer to a *short int* argument.

l (ell) A following integer conversion corresponds to a *long int* or *unsigned long int* argument, or a following **n** conversion corresponds to a pointer to a *long int* argument, or a following **c** conversion corresponds to a *wint_t* argument, or a following **s** conversion corresponds to a pointer to *wchar_t* argument.

ll (ell-ell). A following integer conversion corresponds to a *long long int* or *unsigned long long int* argument, or a following **n** conversion corresponds to a pointer to a *long long int* argument.

L A following **a**, **A**, **e**, **E**, **f**, **F**, **g**, or **G** conversion corresponds to a *long double* argument.

j A following integer conversion corresponds to an *intmax_t* or *uintmax_t* argument.

z A following integer conversion corresponds to a *size_t* or *ssize_t* argument.

t A following integer conversion corresponds to a *ptrdiff_t* argument.

The conversion specifier

A character that specifies the type of conversion to be applied. The conversion specifiers and their meanings are:

d,**i** The *int* argument is converted to signed decimal notation. The precision, if any, gives the minimum number of digits that must appear; if the converted value requires fewer digits, it is padded on the left with zeros. The default precision is 1. When 0 is printed with an explicit precision 0, the output is empty.

o,**u**,**x**,**X** The *unsigned int* argument is converted to unsigned octal (**o**), unsigned decimal (**u**), or unsigned hexadecimal (**x** and **X**) notation. The letters **abcdef** are used for **x** conversions; the letters **ABCDEF** are used for **X** conversions. The precision, if any, gives the minimum number of digits that must appear; if the converted value requires fewer digits, it is padded on the left with zeros. The default precision is 1. When 0 is printed with an explicit precision 0, the output is empty.

e,**E** The *double* argument is rounded and converted in the style [−]d**.**ddd**e**±dd where there is one digit before the decimal point character and the number of digits after it is equal to the precision; if the precision is missing, it is taken as 6; if the precision is zero, no decimal point character appears. An **E** conversion uses the letter **E** (rather than **e**) to introduce the exponent. The exponent always contains at least two digits; if the value is zero, the exponent is 00.

f,**F** The *double* argument is rounded and converted to decimal notation in the style [−]ddd**.**ddd, where the number of digits after the decimal point character is equal to the precision specification. If the precision is missing, it is taken as 6; if the precision is explicitly zero, no decimal point character appears. If a decimal point appears, at least one digit appears before it.

g,**G** The *double* argument is converted in style **f** or **e** (or **F** or **E** for **G** conversions). The precision specifies the number of significant digits. If the precision is missing, 6 digits are given; if the precision is zero, it is treated as 1. Style **e** is used if the exponent from its conversion is less than −4 or greater than or equal to the precision. Trailing zeros are removed from the fractional part of the result; a decimal point appears only if it is followed by at least one digit.

a,**A** For **a** conversion, the *double* argument is converted to hexadecimal notation (using the letters abcdef) in the style [-]**0x**h**.**hhhh**p**±d; for **A** conversion the prefix **0X**, the letters ABCDEF, and the exponent separator **P** is used. There is one hexadecimal digit before the decimal point, and the number of digits after it is equal to the precision. The default precision suffices for an exact representation of the value if an exact representation in base 2 exists and otherwise is sufficiently large to distinguish values of type *double*. The digit before the decimal point is unspecified for non-normalized numbers, and nonzero but otherwise unspecified for normalized numbers.

c If no **l** modifier is present, the *int* argument is converted to an *unsigned char*, and the resulting character is written. If an **l** modifier is present, the *wint_t* (wide character) argument is converted to a multi-byte sequence by a call to the **wcrtomb** function, with a conversion state starting in the initial state, and the resulting multi-byte string is written.

s If no **l** modifier is present: The *const char* * argument is expected to be a pointer to an array of character type (pointer to a string). Characters from the

array are written up to (but not including) a terminating **NUL** character; if a precision is specified, no more than the number specified are written. If a precision is given, no null character need be present; if the precision is not specified, or is greater than the size of the array, the array must contain a terminating **NUL** character. If an **l** modifier is present: The *const wchar_t* * argument is expected to be a pointer to an array of wide characters. Wide characters from the array are converted to multi-byte characters (each by a call to the **wcrtomb** function, with a conversion state starting in the initial state before the first wide character), up to and including a terminating null wide character. The resulting multi-byte characters are written up to (but not including) the terminating null byte. If a precision is specified, no more bytes than the number specified are written, but no partial multi-byte characters are written. Note that the precision determines the number of *bytes* written, not the number of *wide characters* or *screen positions*. The array must contain a terminating null wide character, unless a precision is given and it is so small that the number of bytes written exceeds it before the end of the array is reached.

p The *void* * pointer argument is printed in hexadecimal (as if by **%#x** or **%#lx**).

n The number of characters written so far is stored into the integer indicated by the *int* * (or variant) pointer argument. No argument is converted.

% A '%' is written. No argument is converted. The complete conversion specification is '%%'.

Appendix B: Date format string

Date format string description

The format string used by L-Vis date controls is equivalent to the format string used by the ANSI-C function strftime. The locale setting on the L-Vis device for the purpose of formatting dates is fixed to U.S. setting, therefore the names of weekdays and months will be in English language only.

Conversion specifiers are introduced by a '%' character, and are replaced as follows:

%a The abbreviated weekday name.

%A The full weekday name.

%b The abbreviated month name.

%B The full month name.

%c The date and time in American writing.

%C The century number (year/100) as a 2-digit integer. (SU)

%C The century number (the year divided by 100 and truncated to an integer).

%d The day of the month as a decimal number (range 01 to 31).

%D Equivalent to %m/%d/%y.

%e Like %d, the day of the month as a decimal number, but a leading zero is replaced by a space.

%E Modifier: use alternative format, see below.

%G The ISO 8601 year with century as a decimal number. The 4-digit year corresponding to the ISO week number (see %V). This has the same format and value as %y, except that if the ISO week number belongs to the previous or next year, that year is used instead.

%g Like %G, but without century, i.e., with a 2-digit year (00-99).

%h Equivalent to %b.

%H The hour as a decimal number using a 24-hour clock (range 00 to 23).

%I The hour as a decimal number using a 12-hour clock (range 01 to 12).

%j The day of the year as a decimal number (range 001 to 366).

%k The hour (24-hour clock) as a decimal number (range 0 to 23); single digits are preceded by a blank. (See also %H.)

%l The hour (12-hour clock) as a decimal number (range 1 to 12); single digits are preceded by a blank. (See also %I.)

%m The month as a decimal number (range 01 to 12).

%M The minute as a decimal number (range 00 to 59).

%n A newline character..

%O Modifier: use alternative format, see below.

%p Either ‘AM’ or ‘PM’ according to the given time value, or the corresponding strings for the current locale. Noon is treated as ‘pm’ and midnight as ‘am’.

%P Like %p but in lowercase: ‘am’ or ‘pm’ or a corresponding string for the current locale

%r The time in a.m. or p.m. notation. In the POSIX locale this is equivalent to ‘%I:%M:%S %p’

%R The time in 24-hour notation (%H:%M). (SU) For a version including the seconds, see %T below.

%s The number of seconds since the Epoch, i.e., since 1970-01-01 00:00:00 UTC.

%S The second as a decimal number (range 00 to 61).

%t A tab character.

%T The time in 24-hour notation (%H:%M:%S).

%u The day of the week as a decimal, range 1 to 7, Monday being 1. See also %w.

%U The week number of the current year as a decimal number, range 00 to 53, starting with the first Sunday as the first day of week 01. See also %V and %W.

%V The ISO 8601:1988 week number of the current year as a decimal number, range 01 to 53, where week 1 is the first week that has at least 4 days in the current year, and with Monday as the first day of the week. See also %U and %W.

%w The day of the week as a decimal, range 0 to 6, Sunday being 0. See also %u.

%W The week number of the current year as a decimal number, range 00 to 53, starting with the first Monday as the first day of week 01.

%x The preferred date representation for the current locale without the time.

%X The preferred time representation for the current locale without the date.

%y The year as a decimal number without a century (range 00 to 99).

%Y The year as a decimal number including the century.

%z The time-zone as hour offset from GMT. Required to emit RFC822-conformant dates (using "%a, %d %b %Y %H:%M:%S %z").

%Z The time zone or name or abbreviation.

%+ The date and time in date(1) format.

%% A literal '%' character.

Some conversion specifiers can be modified by preceding them by the E or O modifier to indicate that an alternative format should be used. If the alternative format or specification does not exist for the current locale, the behavior will be as if the unmodified conversion specification were used. (SU) The Single Unix Specification mentions %Ec, %EC, %Ex, %EX, %Ry, %EY, %Od, %Oe, %OH, %OI, %Om, %OM, %OS, %Ou, %OU, %OV, %Ow, %OW, %Oy, where the effect of the O modifier is to use alternative numeric symbols (say, roman numerals), and that of the E modifier is to use a locale-dependent alternative representation.

Revision History

Date	Version	Author	Description
2004-11-03	1.1	NR	Initial revision V1.1
2004-06-04	1.2	NR	New screenshots, added configuration chapter, fixes
2006-01-24	1.3	NR	Changes for L-VIS 3E100
2006-04-04	1.5.1	NR	Added documentation for color mapping, theft protection. Updates after review.
2006-10-13	2.0.0	CZ	Rewrote a large part of the manual to make it more useful (hopefully) based on user feedback. The example and solution sections remain unchanged for now. The new BACnet model LVIS-ME200 is now also covered by this manual.
2006-02-08	2.0.4	CZ	Added new sections about data point management and standard solutions, as well as some smaller improvements and corrections.

Glossary of Terms

Dynamic Network Variable

Network variable, which is generated dynamically during system integration.

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